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ENGINEERING:

An Illustrated Weekly Journal.

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ROCHESTER.
Steam Road Rollers & Tractors.
9037

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, pages 29 and 81.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2.
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HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 9109

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Thos. Piggott & Co., Limited,
BIRMINGHAM. 7411
See Advertisement last week, page 107.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9063

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9105

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MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 9108

Petter Oil Engines.
For Paraffin and Crude Oil.
Sizes 2½ B.H.P. and upwards.
Petters Limited, Yeovil.
Sizes 10 to 500 B.H.P.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Oct 9753

Electric Transporters.
S. H. HEYWOOD & CO., LTD., REDDISH. 9026

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C. 3. 1834

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 84, Robertson Street, Glasgow.
See Advertisement page 68, Oct. 14.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 9063
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Worm Wheels cut up to 13 ft. diam.
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Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD, BROAD STREET, PORTSMOUTH.

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LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1899.
Address, BURNETT AVENUE, HULL.
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Oil Fuel Appliances.
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
35, THE TEMPLE, DALE STREET, LIVERPOOL; and 4078
MESSRS. BUCKNALL & RICHES, 8, SOUTHAMPTON ROW, LONDON, W.C. 1.
Telephone No.: Museum 6684.
NAVAL OUTFITS A SPECIALTY.

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 113, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: Od 8353
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Henry Butcher & Co.,
VALUERS AND AUCTIONEERS
to the
ENGINEERING AND ALLIED TRADES,
ALSO FOR
PLANT AND MACHINERY. 8134
63 and 64, CHANCERY LANE, W.C. 2.

Electric Lifts
(UP TO 35 TONS.)
9026
S. H. HEYWOOD & CO., LTD. REDDISH.

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28.

Locomotive Shunting Cranes

Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 9264
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W. 1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES.
HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 112. 9091

Machine and Engineering
WORK of all descriptions undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT AOT.—ROSSER & RUSSELL, LTD., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9311

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported Upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E. 15. 1794

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 9241
THE GLASGOW ROLLING STOCK AND PLANT WORKS.

Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od3382

Patents DESIGNS AND TRADE MARKS IN ALL COUNTRIES.
E. P. Alexander & Son,
CHARTERED PATENT AGENTS,
306, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7434. Od 585

CHANTIERS & ATELIERS.
Augustin-Normand
61, rue de Perrey—LE HAVRE (France). 3890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Electric Cranes.
9026
S. H. HEYWOOD & CO., LTD., REDDISH.

The National Foremen's
ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.
(Registered under the Trade Union Act.)
An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. F 601
All communications to— Head Offices—
H. W. REID, 96, Belgrave Road
General Secretary. Victoria, London, S.W. 1.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W. 1.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } Row's Patents
STEAM AND GAS KETTLES,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS,
WATER SOFTENING and FILTERING. 5123

Yarrow Patent Water-tube Boilers.
9564
Messrs. YARROW & CO. UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9510
See Full Page Advt., page 70, Oct. 14.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Spur & Bevel Gear Generating
ATTACHMENTS FOR SHAPERS.
Spur Gear 12 in. Straight & Spiral Bevels 6 in. and 9 in. Through Merchants only. 9704
MATTERSON, LIMITED, Shawclough, Rochdale.

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 6350
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Taylor & Challen Presses
8136
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full Page Advertisement page 68, Oct. 14.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 9674

"Spencer-Hopwood" Patent Boilers. *See page 29*
Sole Makers:
SPENCER-BONECOURT, LTD., 9262
Parliament Mansions, Victoria St., London, S.W.

GRAPHITED OIL. **"OILDAG"** (Reg.) BRAND.
GRAPHITED WATER. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE. **"GREDAG"**
9605

E. G. Acheson Ltd.,
Dept. E.. (Sole Manufacturers.) Works:
40, WOOD ST., S.W. 1. PLYMOUTH.

Locomotive Traversers
(ELECTRIC).
9026
S. H. HEYWOOD & CO., LTD., REDDISH.

Phone—Holb. 841. Tele—Andrubo, Holb., London.
Andrews & Beaumont,
(Ewart S. Andrews, B.Sc.; J. Harold Beaumont)
PATENT AGENTS. 9606
29, Southampton Buildings, London, W.C. 2.

S. Sokal, CHARTERED PATENT AGENT.
1, Great James Street, Bedford Row, London, W.C.1.
T.N. 4515 Museum. 9675

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
9727
See half-page Advertisement, page 74, Sept. 30.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

Chief Engineer: C. E. Stromeyer, M.I.C.E.

Founded 1854 by Sir William Fairbairn.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

East London College

(University of London),

Mile End Road, E. 1.

A COURSE OF SEVEN LECTURES will be given at the College by Engineer-Commander B. W. Knott, R.N., Superintendent of the Admiralty Engineering Laboratory at West Drayton, on *Diesel and Semi-Diesel Oil Engines, the Present Position of the Heavy Oil Engine and the Problems involved in its further Development.*

The course will commence on Thursday evening, October 27th, at 6ix p.m., and will be continued on the succeeding Thursdays, November 3rd, 10th, 17th, Friday, November 25th, and Thursdays, December 1st and 8th at the same hour.

Fee for the Course £1 1s.

Students attending University Courses at Colleges and Institutions of the University, 10s. 6d.

E. J. Wignall,
Registrar. S 347

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all Engineering Exams. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. Trevor W. Phillips, B.Sc. (Hons.). Assoc.M.Inst.C.E., M.R.S.I., etc., 8–10, Trafford Chambers, 58, South John Street, Liverpool. 9256

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. Knowles, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9049

Inst.C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 35 years' professional experience. Address, 7434, Offices of Engineering.

TENDERS.

The Ministry of Public Works, Egyptian Government, are calling for

Tenders for the Supply of

Pumping Plant and Machinery to be erected by the Contractors at Atf.

The Plant to include four Diesel or Semi-Diesel Engines, each directly coupled to a Turbine or Centrifugal Pump, with all necessary pipes, etc.

Conditions of Tender and Specification, price 10s., can be obtained from :—

The Inspecting Engineer, S 297
Egyptian and Sudan Governments,
Queen Anne's Chambers,
Westminster, S.W. 1.

Calcutta Electric Supply Corporation, Ltd.

The Directors of the Calcutta E. S. Corporation, Ltd., invite

Tenders for the Supply of

Paper Insulated, Lead Covered Cables, Bitumen Sheathed Cables, V.I.R. Cables, and Joint Boxes, to Specification No. 72.

The above Specification can be seen at, and obtained from, the Offices of the Consulting Engineers, Messrs. Kennedy & Donkin, 17, Victoria Street, London, S.W. 1, on and after Thursday, the 20th instant. Tenders are to be sent in by November 9th, 1921.

Ivor C. Thomas,
3 & 4, Clement's Inn, Secretary.
Strand, W.C. 2.
14th October, 1921. S 334

The South Indian Railway Company, Limited, are prepared to receive

Tenders for the Supply of :—

Rails and Fishplates.

60 lb. per yard B.S. Bull-headed Rails & Fishplates.
90 lb. ditto ditto ditto
Fishplates for 41½ lb. Flat-bottomed Rails.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1, on Monday, the 24th instant.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Rails and Fishplates," must be left with the undersigned not later than Twelve noon on Friday, the 4th November, 1921.

The Directors to not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 20s. for each copy of the Specification.

Copies of the Drawings may be obtained at the Office of Messrs. Robert White & Partners, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

A. Muirhead,
Managing Director.
91, Petty France, S.W. 1.
19th October, 1921. S 378

City of Leicester.
Waterworks Department.
Cast-Iron Pipes.

The Water Committee of the City of Leicester invite

Tenders for the Supply and

Delivery of about 2,700 tons of 27 in. diameter CAST-IRON PIPES.

Conditions of Contract, Specification and Form of Tender may be obtained by Foundry Companies or their Agents from the Undersigned.

Sealed Tenders upon the form supplied endorsed "27 in. diameter Cast-Iron Pipes," are to be delivered to the undersigned on or before the 14th November next.

The Committee do not bind themselves to accept the lowest or any Tender.

G. T. Edwards, M.Inst.C.E.,
Water Engineer and Manager.
Waterworks Office,
Bowling Green Street, Leicester.
October 18th, 1921. S 339

London County Council.

Tenders are Invited for the

Purchase and Removal of One 3,500 K.W. Generating Set, Spare Parts, Etc.

The Plant may be inspected at the Council's Tramway Power Station, Hoskins Street, East Greenwich, between the hours of Nine a.m. and Five p.m. on any week day except Saturday, from 24th October to 14th November, 1921, both dates inclusive, upon production of the tender form.

Particulars and Forms of Tender may be obtained from the General Manager, London County Council Tramways, 23, Belvedere Road, Lambeth, S.E. 1.

No Tender will be considered if received at County Hall, Spring Gardens, S.W. 1, after Twelve noon on Tuesday, 15th November, 1921.

The Council does not bind itself to accept the highest or any Tender.

James Bird,
Clerk of the London County Council. S 352

County Borough of Wallasey.

Seacombe Ferry Improvements.

The Corporation of Wallasey invite

Tenders for the Carrying Out

of that portion of the above Work, denominated work "B" NEW FLOATING ROADWAY, and Work "C" CUT OUT FOR NEW FLOATING ROADWAY, and works in connection therewith, in accordance with the detailed Plans and Specification of Messrs. Wilton & Bell, Consulting Civil Engineers, Westminster Chambers, 1, Cressball Street, Liverpool, at whose office copies of the Specification and Drawings may be seen.

Contractors desiring to obtain copies of Plans and Specification and Schedule of Quantities, may do so on payment of a fee of £2 2s. for each work, or of £3 3s. for the two Works, which fees will not be returnable.

Tenders on the Form of Tender provided must be delivered to the undersigned in a sealed envelope endorsed "Tender for Seacombe Ferry Improvements, Works B and/or C," not later than Twelve Noon, Saturday, November 5th, 1921.

Geo. Livsey,
Town Clerk.
Town Hall, Wallasey.
7th October, 1921. S 347

The Bengal and North Western Railway Company, Limited.

The Directors are prepared to receive

Tenders for the Supply of:—

(A) 250 C.G. WAGONS (complete) and FITTINGS for 300 Wagons.
(B) MATERIALS for Construction of 300 Wagons.
(C) 1,100 pairs of WHEELS AND AXLES.
(D) 1,200 AXLE BOXES.
(E) 1,200 LAMINATED SPRINGS.
(F) 1,200 VOLUTE SPRINGS.

as per Specifications to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Wagons (A) or (B)" or as the case may be, are to be lodged not later than Noon on Monday, the 14th day of November, 1921.

For Specifications (A) and (B) a fee of £2; (C) £1; (D) (E) and (F) 10s. each will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
B. A. Neville,
Managing Director.
237, Gresham House, Old Broad Street.
London, E.C. 2.
18th October, 1921. S 348

East Indian Railway.

The East Indian Railway Company is prepared to receive

Tenders for the Supply and

Delivery of :—

1. PAINTS, &c.
2. WOOD SCREWS, NAILS, &c.
3. BUNTING.
4. 20 BOGIE CARRIAGES.

as per Specifications to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, not later than Eleven o'clock a.m., marked "Tender for Paints, &c.," or as the case may be, for Nos. 1, 2 and 3, on Wednesday, the 2nd day of November, proximo, and for No. 4, on Wednesday, the 9th day of November, proximo.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.

For each specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By Order,
G. H. Lillie,
Secretary.
Nicholas Lane, London, E.C. 4.
19th October, 1921. S 368

Borough of Aylesbury.

Electric Motors and Pumps.

Tenders are Invited for

Supplying and Fixing complete—

Contract No. 1.

TWO VERTICAL A.C. ELECTRIC MOTORS and FIVE HORIZONTAL A.C. ELECTRIC MOTORS, &c.

Contract No. 2.

TWO VERTICAL CENTRIFUGAL PUMPS and THREE HORIZONTAL CENTRIFUGAL PUMPS, Delivery Pipes, Valves, &c., at the Sewage Works, Bicester Road, Aylesbury. (Note.—In the event of a Contractor quoting for both Contracts he must send separate Tenders in for each Contract.)

Plans and Specification may be seen on application to the undersigned upon payment of £1 1s., which will be returned on receipt of a *bona fide* Tender and return of all documents.

Sealed Tenders, endorsed "Tender for Electric Motors and Pumps," together with Drawings, to be delivered to my Office not later than Twelve o'clock noon on Friday, November 11th, 1921.

Contractors desirous of being shown over the site are requested to make arrangements with Engineer and Surveyor.

The Council does not bind itself to accept the lowest or any Tender.

WM. HAROLD TAYLOR,
Borough Engineer and Surveyor.
Town Hall,
Aylesbury.
October 21st, 1921. S 361

Siam State Railways.
Notice.

Tenders are Invited for the

Supply of 500 Pairs WHEELS and AXLES.

Specifications and drawings may be obtained against payment of £1 from Messrs. C. P. Sandberg, 40, Grosvenor Gardens, London, S.W. 1.

Sealed Tenders, with the inscription "Tender for 500 Pairs Wheels and Axles 2464," must be forwarded to the undersigned, at whose office in the City of Bangkok, Siam, they will be received up to Two p.m., on the 1st February, 1922, at which place and hour the tenders will be publicly opened and read.

Right is reserved to reject any or all Tenders, and to accept any Tender which in the opinion of the undersigned is to the best interests of the Siam State Railways.

Purachatra,
Commissioner General of State Railways.
Department of State Railways,
Bangkok, 13th September, 1921. S 377

London County Council.

Tenders are Invited for the

Manufacture, Supply, Delivery and Erection of WATER TUBE BOILERS, with SUPERHEATERS and ECONOMISERS, Etc.

The Specification, Form of Tender and general conditions, may be obtained from the Clerk of the Council, County Hall, Spring Gardens, S.W. 1, on payment of a deposit of £2 to the Cashier of the Council, which amount will be refunded on receipt of a *bona fide* Tender.

Tenders must be addressed to the Clerk of the Council and delivered to the County Hall, Spring Gardens, S.W. 1, not later than Four p.m. on Monday, 28th November, 1921. Any Tender received after that time will not be considered.

The Council does not bind itself to accept the lowest or any Tender.

James Bird, S 351
Clerk of the London County Council.

APPOINTMENTS OPEN.

Research Department,
Royal Arsenal, Woolwich.

Directorate of Metallurgical Research.
Assistant I.

Required, one Assistant

Metallurgist.

Candidates must have good academic qualifications and at least two years' experience of metallurgical research. Some works experience would be regarded as an additional qualification.

Initial Salary £370 and bonus. (Total emoluments at present approximately £630 8s. 0d.)

The above post carries superannuation under a scheme similar to that of the Federated Universities.

Annual leave, six weeks.

Applications in writing with copies of testimonials and references to any published work should be made to the

Chief Superintendent,
Research Department,
Royal Arsenal,
Woolwich,

from whom the conditions of employment may be obtained.

S 279

City of Birmingham Electric Supply Department.
Assistant Resident Power Station Engineer and Four Power Station Shift Engineers.

The Birmingham Corporation is prepared to receive

Applications from Suitable

Candidates for the following POSITIONS on the Staff of the Electric Supply Department :—

One Assistant Resident Power Station Engineer, Minimum Salary in accordance with National Joint Board Schedule, applicable to Grade 5, Class G.

Four Power Station Shift Engineers, Minimum Salary in accordance with National Joint Board Schedule, applicable to Grade 8, Class G.

Candidates must have had a sound theoretical and practical training in Electrical and Mechanical Engineering and be thoroughly experienced in the operation of a modern Power Station. Preference will be given to Corporate Members of the Institution of Electrical Engineers.

The successful candidates will be required to undergo an approved medical examination and contribute to the Corporation Superannuation Scheme.

Forms of application for the above appointments may be obtained from the undersigned, and when completed should be sent to these offices with copies of not more than three most recent testimonials as to experience, ability and character. Applications endorsed "Assistant Resident Engineer," or "Shift Engineer," as the case may be, must be sent in not later than Monday, October 31st, 1921.

R. J. Jennings, Secretary.
14, Dale End, Birmingham.
5th October, 1921. S 378

Works Superintendent

Required by manufacturers of Electric Accumulators, Midland counties. Must have good mechanical engineering experience and be accustomed to handle men. Knowledge of accumulator construction not essential.—Address, S 363, Offices of Engineering.

Wanted at Once, First-class

Thoroughly Experienced and Energetic Blast Furnace Manager for up-to-date Mechanically-charged Furnaces, well versed in production of Basic and Foundry Irons from lean ores.—Apply, stating age, experience and salary required, to John Lysaght, Ltd., Normanby Park Steel Works, Scunthorpe. S 309

Mechanical Engineer, under

35, unmarried, WANTED for Baghdad for Charge of Workshops and Machinery Sales. Initial salary Rs.1000 per month, with quarters and benefits of Provident Fund.—State age, education, experience, war service, to K., Winchester House, E.C. 2. S 356

Bombay Port Trust.
Engineering Assistant.

The Trustees to the Port of Bombay require the

Service of an Engineering

Assistant with good experience of girder, bridge and roof steelwork design, building construction and heavy masonry work. Should preferably have obtained experience in connection with railway or dock work and have been for some time with a good contractor. Capable of preparing designs and drawings and making calculations under the direct supervision of an Executive Engineer. Salary, Rupees 850 per month rising annually by Rupees 30 per month to Rupees 940 and if married with such married officer's house allowance as he may be eligible for under the rules of the service. Three years' agreement.—Applications, in writing only, stating age, education, technical qualifications, etc., with copies of testimonials to the Consulting Engineers, Bombay Port Trust, 2, Queen Anne's Gate, Westminster, S.W. 1. S 313

Supervising Erecting Engineer

Wanted, for Firm in the North. Applicants must have had experience in the erecting, wiring, and running of large Rolling Mills and other classes of electrical apparatus.—Address, with particulars of training, age, experience, and salary required, S 367, Offices of Engineering.

Process Engineer Wanted by

large Electrical Firm in the North. Preference given to a man who has had a first-class experience of Machining and Assembling Operations on Electrical Apparatus. Applicants must be able to process operations direct from drawings and to support process by extensive practical knowledge. Applications should give full particulars of experience, positions held, age, and salary required.—Address, S 308, Offices of Engineering.

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Candidates, age 35 to 45, must be qualified Civil Engineers, preferably Corporate Members of the Institution of Civil Engineers, who have had considerable experience in the erection of machinery. —Apply, at once, in writing, giving age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/Nigeria, 11186. S 369

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REQUIRED for aircraft work. Apply stating age, salary required, and aircraft experience.—Address, S 346, Offices of Engineering.

Tangyes Limited Require the

SERVICES of a HEAD DRAUGHTSMAN with good experience of Pump work, Steam Engines, and Hydraulic work. State qualifications, age and salary.—Replies will be treated confidentially, and should be addressed, CHAIRMAN, Tangyes Limited, Cornwall Works, Birmingham. S 286

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REQUIRED, by the Government of Nigeria, for the Public Works Department, for two tours each of not less than 12 and not more than 18 months, with possible extension. Salary £500 per annum, rising to £560 per annum by annual increments of £12. Outfit allowance of £45 on first appointment. Quarters free of rent and free passages. Liberal leave in England on full salary. Candidates age 25 to 40, must have had experience in the sinking of concrete cylinders for bridge foundations, and of bridge building.—Apply at once, by letter, mentioning this paper and stating age and full particulars of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting M/10765. S 349

SITUATIONS WANTED.

Shipyard Manager (41), wide

experience, merchant work home and abroad Shortly Open for Re-engagement, preferably Great Britain or Northern Europe. Expert in latest methods steel ship construction. Highest references. —Address, S 340, Offices of Engineering.

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Mechanical, Electrical, Good Connection, Government Departments, Railways, Public Bodies, Principal Contractors, OPEN for good ENGAGEMENT. London, East Coast, Southern Counties to represent manufacturers. Knowledge of Engines, Motors, Pneumatic Plant, Cables, all classes of tubes. The man who can get there. Salary and commission arrangements expected £1,000 per annum.—Address, S 344, Offices of Engineering.

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wide experience in the designing and manufacture of Steel Bridges, Industrial Buildings, and General Steelwork, DESIRES APPOINTMENT. Fully capable of undertaking the supervision of a technical staff, site erection, or similar responsible position.—Address, S 370, Offices of Engineering.

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13 years' good general experience as Manager and Foreman; also costing and travelling experience, SEEKS responsible POST in any capacity.—Address, S 375, Offices of Engineering.

MAPPING FROM AEROPLANE PHOTOGRAPHS.

By R. B. UNWIN, B.Sc.(Eng.), London.

DURING the war a considerable area of Northern France and Belgium was entirely re-mapped, largely from aeroplane photographs, so as to provide the large-scale accurate maps which were necessary in stationary warfare to show the elaborate trench systems and to enable the artillery to lay their guns on invisible targets.

The photographs were taken by a camera rigidly fixed to the underside of the aeroplane. So, if the plane were slightly tilted when the photograph was taken, the lens of the camera would not be pointing vertically downwards, and in consequence the photograph would give a distorted view of the ground instead of a true map. A largely distorted photograph of a chess board would appear as in Fig. 1; point A being furthest from the camera. From this it will be seen that the scale of a distorted photograph varies not only in different parts; but in the same part lines at right angles have different scales. Compare the lengths A and B, which should be equal.

This is the difficulty which arises when attempting to form an accurate "mosaic" map by fitting together suitable portions of a number of aeroplane photographs. Even when all the photographs are taken from the same height and consequently the average scales of them are all the same, there are sure to be a few slightly distorted photographs. So the result does not give a true representation of the ground.

In mapping from aeroplane photographs it is necessary, therefore, to form a "framework" on which to hang the photographs. The "framework" consists of a number of points. The exact position of these points on the ground must be known, and they must be such as can be identified on the photographs. The primary points used were the original trigonometrical survey points, usually church spires. These were not close enough together to form a complete framework, so intermediate points had to be fixed.

If the ground were accessible, *i.e.*, lay behind our lines, a surveyor with a plane table working from the trignometric points fixed the position of a number of cross roads, as these could be identified on the photographs very easily. Naturally this did not take long as the surveyor did not trouble about any detail, but merely marked the position of cross roads or other suitable points on his plane table at about 500 yard intervals. If the ground were inaccessible, *i.e.*, lay behind the enemies' lines, these intermediate points could be fixed from the aeroplane photographs in one of the ways now to be described.

However much distorted a photograph is, a straight line on the ground will appear as a straight line on the photograph, provided the difference in level of any points on the line is not great compared to the height from which the photograph was taken. This applied with sufficient accuracy to the undulating country under consideration. From this it follows that, if there is a photograph upon which four trignometrical points are shown and a cross roads lies upon the intersection of the lines joining these four points, then the correct position on the map for the cross roads will be at the intersection of the corresponding straight lines.

Also, if there are four points C, D, E F (see Fig. 2), on a photograph and their correct position on the map be *c*, *d*, *e*, *f*, then any other point X on the photograph can be plotted in its correct position *x* on the map as follows. First taking E

Fig. 1.

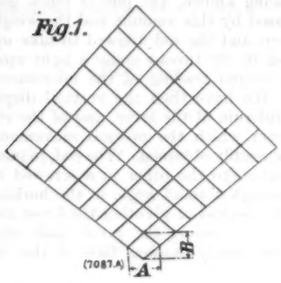


Fig. 2.

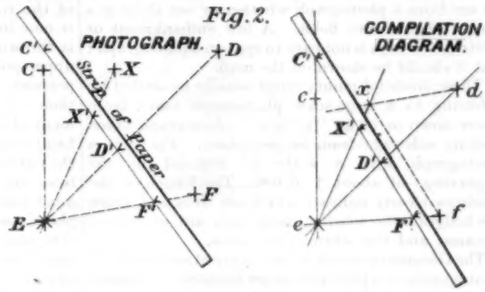


Fig. 3. PORTION OF COMPILATION DIAGRAM.

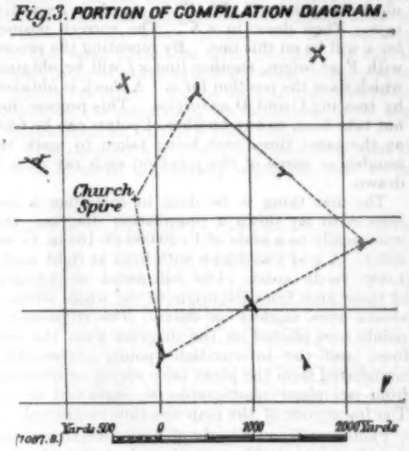


FIG. 4.

FIG. 5.

as origin, place a strip of paper across the photograph, lay a straight edge along C E and mark the point C′ on the strip of paper where this line cuts it. Mark points X′, D′, F′, on the paper in the same way. On the map draw the rays *e c*, *e d*, *e f*. Lay the strip of paper across these rays and move it about until the points C′, D′, F′ lie on their respective rays. Then draw in *e* X′. The correct position for *x* will be on this line. By repeating the process with F as origin, another line *x f* will be obtained which fixes the position for *x*. A check is obtained by treating C and D as origins. This process does not take long, as any number of points can be fixed at the same time, care being taken to mark the number or name of the point on each ray as it is drawn.

The first thing to be done in compiling a new map is to lay down a compilation diagram, this was usually to a scale of 1 : 20,000 (3·168 in. to the mile). A grid was drawn with lines at right angles 1,000 yards apart. The calculated co-ordinates of these lines from the origin of the whole series of sheets were marked on them. The trignometric points were plotted on the diagram from the grid lines, and the intermediate points were either transferred from the plane table survey or obtained from aeroplane photographs as explained above. The framework of the map was thus completed.

Photographs covering the area were next examined and the most suitable ones selected, each one having on it at least four of the points the position of which had been fixed on the compilation diagram. As a rule photographs taken from a greater height provided they were clear, were better, as they were less liable to be much distorted.

After the whole area had been covered by suitable photographs, the negatives of them were obtained from the Royal Air Force. Four or more of the fixed points were identified on each negative and fine lines drawn on the back of it connecting them up. A piece of tracing paper was placed over the corresponding points on the compilation diagram and lines drawn connecting them up. Fig. 3 shows a portion of a compilation diagram, reduced to about one-third the actual size; the dotted lines being the lines which would be drawn on a piece of tracing paper joining up the six fixed points.

Fig. 4 is an aeroplane photograph with lines joining up the corresponding six points. If the photograph is free from distortion these two figures would be similar (the angles of one equal to the corresponding angles of the other). In this case the scale of the original photograph was approximately 1 : 20,000 (reduced to 1 : 25,000 in the engraving), so the two figures were about the same size. Each negative was marked up in this way, and each provided with a piece of tracing paper giving the correct relative position of its fixed points.

The negative was then placed in an enlarging camera and the image projected on to a vertical board fitted with an adjustable ball and socket joint. The piece of tracing paper was pinned to the board, which was then moved backwards or forwards and tilted one way or the other until the projected image of the lines on the negative exactly corresponded with the lines drawn on the tracing paper. A piece of sensitised paper was then substituted for the tracing paper and a print taken. Thus a print to the exact scale required and free of distortion was obtained.

It should be noted that if only three points are taken and joined to form a triangle, there are six different ways in which it is possible to make the projected image of the triangle fit the true triangle on the tracing paper; and only one of these is correct. So it is necessary to have at least four points. In practice it is not advisable to use any portion near the edge of the photograph, as this is liable to have distortion due to the lens of the camera. The prints thus obtained were not clear enough to trace from, so the roads, &c., were inked up in vermilion. This did not take long and could be done by comparatively unskilled draughtsmen.

The finished map was drawn on tracing linen, the fixed points being first marked on it from the compilation diagram and then the features traced from the inked up prints of the photographs, their correct position being registered by the fixed points. The draughtsman had the original aeroplane photographs by him to refer to if necessary. By tracing direct from the prints, bends of roads, windings of streams, shapes of woods, &c., could be put in with great accuracy and much more quickly than by surveying them from the ground.

If possible, before the map was printed a field revision was carried out. For this purpose a ferrogallic or ordoverax pull was taken of the map, cut up into sections and mounted on cardboard. Topographers then went quickly over the ground noting any omissions or errors in interpreting the photographs. For example, it is not always easy to see from a photograph whether or not there is a fence between two fields. A low embankment or cutting 6 ft. high is not easy to spot on a photograph; but it should be shown on the map.

These doubtful points could usually be settled by referring to a large-scale photograph taken from lower down or to an "oblique" photograph taken looking sideways from an aeroplane. Fig. 5 is a photograph with a scale—as reduced in the engraving—of about 1 : 6,400. The length of the shadows clearly indicate which are trees and which are hedges; the winding dark lines are, of course, streams, and the white lines roads.

The Germans printed in the corner of some of their photographs two little indicators to show the amount of tilt in each direction of the aeroplane at the moment the plate was exposed. From this information, no doubt, they corrected the distortion of the photograph. But we did not make use of any such device. There should be a great future for mapping from aeroplane photographs in undeveloped countries, especially where the ground is not readily accessible.

A MACHINE FOR THE MEASUREMENT OF INTERNAL DIAMETERS.

By G. A. Tomlinson, B.Sc. (of the National Physical Laboratory).

The accurate measurement of an internal diameter, either plain or screwed, has always presented greater difficulties than the corresponding external measurement. A method of making this type of measurement has recently been developed at the National Physical Laboratory, Teddington, which gives a high order of accuracy, and allows the inside diameter to be explored to any extent that may be necessary.

Hitherto the effective diameter of a ring screw has commonly been examined between prescribed limits by means of very accurate check gauges, of which it is essential to have a full form "go" check with diameters on the lower limits and a "not go" effective diameter check made on the upper limit of diameter. This method proves satisfactory when a large number of specimens of the same size have to be dealt with, but when only a limited number of screws, perhaps only one, have to be examined, the expense and delay involved in the production of these check gauges becomes prohibitive. Further, it is often not enough to know that the internal diameter is between two limits, and the actual value may be required, with some knowledge of the variations occurring.

The principle of the new method is illustrated in Fig. 1. The screw is held with its axis horizontal, and the diameter is measured in terms of the length of a ball-ended rod L M which is screwed into the thread. The diameter of the ball is chosen so that it makes contact with the threads at or near the centre of the flanks. The length of the rod is such that there is a definite amount of clearance relative to the diameter of the ring, and it can, therefore, be displaced through a certain vertical distance *y*, from one horizontal position L M, in which it is in contact with the flanks at each end, to another such horizontal position $L^1 M^1$ on the opposite side of the axis. This vertical displacement is accurately measured, and from this result and the known length of the rod the effective diameter can be obtained.

The displacement measurement is illustrated diagrammatically in Fig. 2. It will be seen that the ball-ended rod A is carried by one end of a lever B pivoted on two steel balls C, on the face of a pile of block gauges D. The further end of the lever has attached to it a small bevelled sector of brass E, of about 3 in. radius, to which the face of a micrometer can be approached to take a reading of the height of this end of the lever. Let us assume that the rod is in the first place to be in its lower position in the screw thread. Then the value of the pile of block gauges is so chosen that the whole lever is approximately horizontal, and by means of a small throw-over weight F the centre of gravity of the lever is brought over to the left of the pivot centre line, giving a light downward bearing pressure to the rod. The reading of the micrometer is then observed. The nominal value of the displacement of the rod being known, the pile of block gauges is now increased by this amount and the weight F is thrown over, and the rod allowed to take up its upper position in the thread under a light upward pressure. A second reading of the micrometer is then taken. We have then the vertical displacement of the fulcrum of the lever, and of the right-hand end, from which the upward movement of the rod can be readily obtained. The rod, in passing from one position to the other in a screwed ring, must turn through a small angle in the horizontal plane, and the method of pivoting the lever allows this movement to occur, the pivot balls sliding easily over the highly-finished face of the block gauge.

In the measurement of a plain ring this movement does not occur, as the rod is at all times in a plane perpendicular to the axis of the hole. This adjustment is initially made by bringing the balls flush with the face of the ring. The micrometer is then set centrally over the sector and subsequently it is only necessary to place the lever so that the sector lies in the centre of the micrometer face, as judged by the eye. Any variations in the inclination of the rod to the axis of the ring that are likely to occur are too small to affect the result. For example, with a micrometer face 0·25 in. in diameter, if it is accepted that the sector can be placed somewhere within the middle fifth, the largest error that can result is two-milliontbs of the diameter to be measured.

A machine which has been designed for the measurement of ring gauges at the Laboratory is shown in Fig. 3. The gauge is held on a suitable face plate mounted on a spindle which is clamped in bearings in a headstock fixed to the base. With the clamps released the spindle can be rotated, and it has also a sufficient range of axial movement to allow the diameter at any part of the gauge to be measured. The lever is a light casting in an aluminium alloy, with a pointer of hard-rolled light alloy riveted to the casting. The casting is bored to take one of the various forms of rod holders that may be used. The lever is provided with a short arm beneath the pointer carrying an adjustable jockey weight, to compensate for the variation in weight of the rod and its holder. The throw-over weight is made in two equal parts, and in adjusting the initial balance of the lever the two parts are placed on opposite sides of the fulcrum.

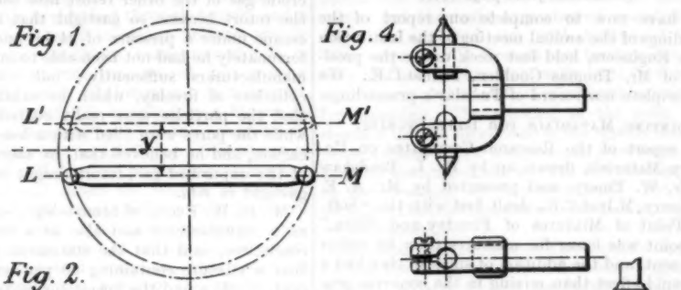
The micrometer is carried by a bracket which simply rests on a faceplate attached to the base of the machine. It can thus be moved quickly into position over the sector on the end of the lever. The bracket also carries a magnifying prism for observing the approach of the face of the micrometer to the sector, illumination being obtained with a lamp and ground glass screen attached to the base. The reading of the micrometer is taken just before it actually touches the sector, and with a sufficiently small curvature this is found to be a very sensitive criterion, and readings can be repeated to within ± 0·0001 in.

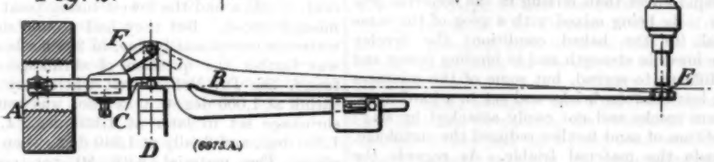
It will be seen from the above description and from the illustration (Fig. 3) that the method may be readily used with very little modification, for making measurements at the lathe without removing the work. For this purpose it is only necessary to arrange suitable supports for the lever and the micrometer bracket on the face of the lathe bed.

It is found convenient to use adjustable rods made in two parts held in a suitable holder. One of these is illustrated in Fig. 4. The gap between the two halves is set by means of slip gauges to give the required centre distance between the balls.

The inner ends of the two sections are made one plane and square with the axis, and the other spherical.

The ratio of the lever is 5 to 1, and it will be clear from Fig. 1 that there is a further magnification of the diametral errors in the displacement of the rod. This depends on the length of the rod in relation to the diameter of the ring, and it is found convenient to have such a length of rod that diameter errors are magnified five times. That is to say, if the diameter of the ring were 0·001 in. greater than its nominal size, then the rod would be displaced by 0·005 in. more than its nominal movement. Thus the error in diameter as observed at the micrometer is magnified 25 times, or, assuming the micrometer reading can be repeated within 0·0001





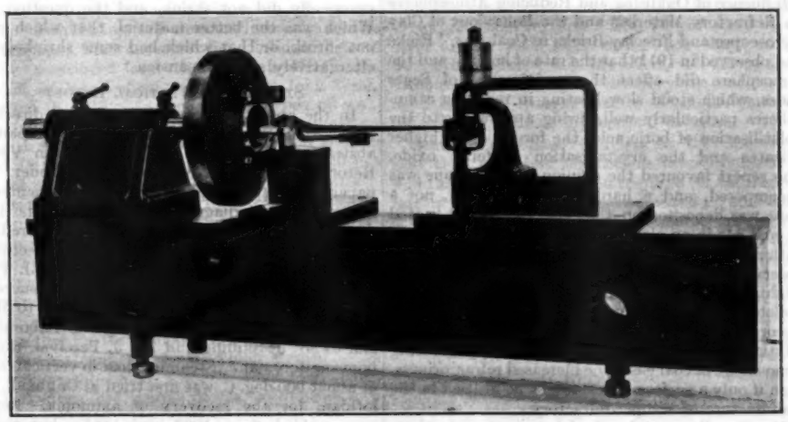


FIG. 3.

in., the sensitivity of the apparatus is of the order 0·000,005 in., and experiments have shown that comparative measurements can be made with certainty to within 0·00001 in. The degree of accuracy attainable in the absolute value of the diameter is discussed later.

It will simplify the explanation of the calculations involved to consider the case of a plain hole first.

Let E = Nominal diameter of ring.
c = Measured diameter of the balls.
L = Length rod between centres of balls.

Then the nominal value of the displacement of the rod will be given by the equation :

$$y^2 = (E - c)^2 - L^2.$$

In practice it is found better to work with a definite magnification five, and the length of rod and nominal displacement are then found as follows :—

$$y = \sqrt{(E - c)^2 - L^2} \quad . \quad . \quad . \quad (1)$$

The magnification can be expressed by $\frac{dy}{dE}$ and $\frac{dy}{dE} =$

$$\frac{E - c}{\sqrt{(E - c)^2 - L^2}} = \frac{E - c}{y} = 5$$

Or

$$y = \frac{E - c}{5} \quad . \quad . \quad . \quad . \quad (2)$$

$$\therefore L^2 = (E - c)^2 - y^2 = (5y)^2 - y^2$$

$$\therefore L = \sqrt{24}\, y = \frac{\sqrt{24}}{5}(E - c) \quad . \quad . \quad (3)$$

Thus from equations (2) and (3) the nominal length of rod and the nominal displacement can be readily found. If the measured displacement differs from the nominal value by δy then the error in diameter is :

$$\delta E = \frac{y}{E - c} \times \delta y = \frac{1}{5}\delta y \quad . \quad . \quad (4)$$

An example of diameter measurement is given below :—

		in.
Nominal diameter of ring	... ...	1·25
Mean measured diameter of balls ($\frac{1}{2}$ in.)		0·12505
Nominal length of rod between centres $= \frac{\sqrt{24}}{5}(E - c)$	... ...	= 1·11240
Measured length of rod end to end	...	1·2373$_5$
Measured length between centres	...	1·1123
Nominal displacement of rod $= \frac{E - c}{5}$		= 0·2250
First micrometer reading R_1	... ...	= 0·3876
Block gauges under lever increased by	...	0·2250
Second micrometer reading R_2	... ...	= 0·6183
$R_1 - R_2$	... ...	= 0·2307

$$\therefore \text{Displacement of rod} = 0{\cdot}2250 - \frac{0{\cdot}2307 - 0{\cdot}2250}{5}$$

$$= 0{\cdot}2238_5,$$

$$\therefore \delta y = -0{\cdot}0011_5,$$

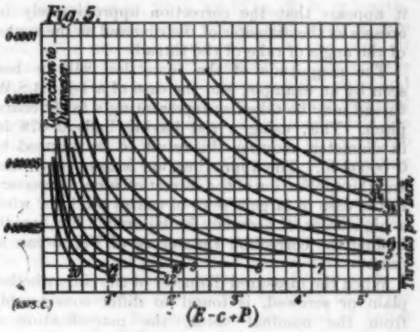
$$\text{and } \delta E = \tfrac{1}{5}\delta y = -0{\cdot}0002_3.$$

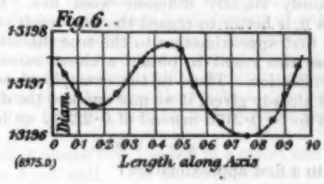
$\therefore$ diameter of ring in terms of the length of rod $= 1{\cdot}2497_7$.

And as the length of the rod is 0·0001 in. less than its nominal size, a correction of this amount must be applied to the measured diameter of the ring, giving the diameter finally as $1{\cdot}2496_7$.

In the case of a screwed ring the calculation of the effective diameter is made in the same way, except that the projected length of the rod in a plane normal to the axis of the screw is now used in the equations. It is obvious that an exact calculation is somewhat complicated, as the two positions of the rod are not quite symmetrical with respect to the diameter of the screw and the projected lengths of the rod in the two positions are slightly different. This difference arises because the rod, although in the same thread in both positions, is slightly more inclined to the axis of the screw in one position than in the other. By the use of an approximation, however, the calculation can be reduced to the same simple form as that of a plain ring.

It is assumed, and it will be shown later, that the error involved is generally negligible, that we can





use in the equation a mean value of the projected length

$$\sqrt{L_0^2 - \frac{p^2}{4}},$$

L_0 being the actual length between the ball centres and p the pitch of the thread.

In the case of a screw the radial distance from the axis to the centre of the ball becomes :

$$\tfrac{1}{2}(E - c + P)$$

where E is now the effective diameter and P is the "P value" of the ball, which can be obtained from the expressions for the P value of the cylinders used for plug screw measurement as given in the "Notes on Screw Gauge Measurement" published by the National Physical Laboratory.* Equation (1) then takes the form :

$$y = \sqrt{(E - c + P)^2 - \left(L_0^2 - \frac{p^2}{4}\right)} \quad . \quad (5)$$

and we have :

$$\frac{dy}{dE} = \frac{E - c + P}{y} = 5$$

$$y = \frac{E - c + P}{5} \quad . \quad . \quad . \quad (6)$$

$$\sqrt{L_0^2 - \frac{p^2}{4}} = \frac{\sqrt{24}}{5}(E - c + P) \quad . \quad (7)$$

$$\delta E = \frac{y}{E - c + P}\delta y = \frac{\delta y}{5} \quad . \quad . \quad (8)$$

from which the diameter is derived as in the case of a plain ring.

The approximation we have made involves a small error, the magnitude of which will now be considered. The determination of the true value of y is rather long, and will not be given, but it leads to the result that the nominal displacement, when the rod has a length given by equation (7) is very closely,

$$y\left(1 + \frac{p^2}{2\pi^2(E - c + P)^2}\right) \quad . \quad . \quad (9)$$

in which y is the approximate value found from

* "*Notes on Screw Gauges*," by the Gauge Testing Staff of the National Physical Laboratory, obtainable from H.M.S.O., price 2*s.* 6*d.*, plus postage.

equation (6). The value taken for y is thus slightly small, and this has the effect of making δy in equation (8) slightly large. Hence we arrive at a value of the effective diameter which is slightly too large.

A correction to the diameter can be applied when necessary by subtracting one-fifth of the small error in the nominal displacement. This correction is thus:

$$\frac{1}{5} \times \frac{p^2 y}{2\pi^2 (E - c + P)^2} = \frac{p^2}{50\pi^2 (E - c + P)} \quad . \quad (10)$$

Writing the last expression as,

$$\frac{p^2 (E - c + P)}{50\pi^2 (E - c + P)^2}$$

it appears that the correction approximately increases as the diameter of the ring and as the square of the angle of rake of the thread.

The magnitude of the correction will be best seen by an example, and the case of a 1-in. B.S.W. thread may be taken as representing a fairly coarse pitch. This, using a rod having balls 0·078 in. in diameter, requires the result to be reduced by 0·00003 in. The approximation is thus very close, and the application of the correction is only necessary in the case of large screws of coarse pitch, or when a high order of accuracy is required. For rapidly finding the correction the curves of Fig. 5 can be used.

When the measured diameter of the ring, whether plain or screwed, is found to differ considerably from the nominal value, the magnification is obviously slightly different from five. In such cases it is better to regard the first result obtained as a first approximation to the true diameter, and to use this result to obtain a closer value of the magnification. Thus, in the example of measurement already given, if we now suppose the displacement to be 0·2175 instead of $0{\cdot}2238_5$, we have:

$$\delta y = -0{\cdot}0075.$$

and to a first approximation:

$$\delta E = \frac{-0{\cdot}0075}{5} = -0{\cdot}0015$$

Then to a first approximation the diameter is small by 0·0016, allowing a further 0·0001 in., as the measured length of the rod is smaller than nominal size by this amount.

Hence more accurately the magnification is:

$$\frac{E - c}{y} = \frac{1{\cdot}1110}{0{\cdot}2175} = 5{\cdot}108$$

and we then get:

$$\delta E = \frac{-0{\cdot}0075}{5{\cdot}108} = -0{\cdot}0014_7.$$

This correction is rarely necessary in gauge measurement, as it is exceptional for a gauge to be so much in error.

Although considerable space has been devoted to the question of small corrections, it should be realised that, in practice, if a measurement within 0·0001 in. is sufficient, these corrections need rarely be applied at all. The method is, however, capable of giving higher accuracy if required, and for this reason these small corrections have been fully treated.

As an illustration of the degree of accuracy of comparative measurements by this method, Fig. 6 is given. This represents the results of measurements of a lapped plain ring gauge, exploring the variations in diameter along the length. The nominal diameter of this ring is 1·3200 in., and a plug of diameter 1·31964 in. will just enter about half-way from one end without being forced, but has to be forced to enter from the other end. It will be seen that the measurements of the ring closely confirm this. They also show an unexpected hollow in the centre of the ring, and a bell-mouthed effect at each end produced by lapping. The possibility of observing these very slight variations in diameter is evidence of the sensitivity of the method.

The accuracy attainable in the absolute value of the diameter is naturally rather lower, and is largely determined by the accuracy of the measurement of the length of the rod. This is usually measured from end to end in a gap made up of standard slip gauges, and the length can be found to within ± 0·00002 in. A small error may arise from the want of roundness of the balls, but it is found that the smaller sizes of balls are very truly spherical, and a considerable proportion can be selected with the diameter uniform to within 0·00001 in. The method is practically free from errors arising from incorrect setting of the ring. A tilt about a vertical axis introduces no error at all, as the lever sets itself correctly with respect to the horizontal diameter. If the vertical diameter is not exactly vertical only a cosine error is introduced into the displacement measurement, and one-fifth of this error appears in the diameter finally.

THE INSTITUTION OF GAS ENGINEERS.

(*Concluded from page 547.*)

We have now to complete our report of the proceedings of the annual meeting of the Institution of Gas Engineers, held last week under the presidency of Mr. Thomas Goulden, M.Inst.C.E.. We first complete our record of Tuesday's proceedings.

Jointing Materials for Refractories.

The report of the Research Committee on Refractory Materials, drawn up by Dr. L. Bradshaw and Mr. W. Emery, and presented by Mr. A. E. Broadberry, M.Inst.C.E., dealt first with the "Softening Point of Mixtures of Fireclay and Silica." That point was lower for mixtures than for either constituent, and the addition of silica to clay had a more rapid effect than mixing in the converse proportion. By being mixed with a grog of the same material (in the baked condition) the fireclay became lower in strength and in binding power and more difficult to spread, but some of the mixtures shrank less between bricks and set to a hard mass, free from cracks and not easily attacked by slag; the addition of sand further reduced the shrinkage, but made the material friable. As regards the "Influence of Oxidising and Reducing Atmospheres on Refractory Materials and the Behaviour of Clay Pyroscopes and Fireclay Bricks in Coal Gas," Rieke had observed in 1911 that the rate of heating and the atmosphere did affect the performance of Seger cones, which stood slow heating in reducing atmospheres particularly well, owing apparently to the volatilisation of boric acid, the formation of higher silicates and the crystallisation of ferric oxide. The report favoured the opinion that methane was decomposed, and a hard graphitic carbon, not a soot, was deposited on the cones. Fireclay heated in coal gas in an electric furnace also covered itself with a protective film of carbon, and it had been observed in England as early as 1898 that the cones might, under certain conditions, merely represent skeleton cones, the core of which had fused out. According to Dr. Mellor, the fusibility of the mixture was not much affected by the reducing atmosphere of coal gas; the increased refractoriness, even if only a surface effect, might be utilised in the manufacture of a super-refractory.

Mr. Broadberry did not wish to enter into these speculations, but he desired to ask the manufacturers of refractory materials whether they did their duty to themselves, their industry and their country in withholding full support from the British Refractory Research Association. That body had been brought into being amid great enthusiasm under the ægis of the Department of Industrial and Scientific Research; the Association undertook to raise a minimum of 2,500*l.* per annum, and the Government undertook to subscribe £ for £ for a period of five years. The gas industry subscribed 150*l.*; the manufacturers, marketers and users had altogether contributed 1,700*l.* in the first year, and the Governnent support would almost certainly be withdrawn. Mr. Broadberry characterised this as a disgrace to a national effort. In the gas industry nearly 1,500,000*l.* were spent annually on repairs and renewals of retort settings, and they subscribed 150*l.* The committee had sent a strong protest to the Association and, though it was not their province to suggest how funds could be raised, they thought that the expense might be proportioned by districting the country or by making a small levy on each manufacturer per ton of clay worked.

Mr. T. Bromley Hardie, deputy-chief engineer to the Gas Light and Coke Company, who was in the chair and who is succeeding Mr. Goulden in the Presidency of the Institution, while pointing out that the gas industry was only one of the users of refractory materials, in which metallurgists and others were more interested, warmly supported the appeal stating that the Institution had laid it down that those interested in the work should subscribe; but the money had not been forthcoming. Dr. R. Lessing, to whom the report, quoting Dr. Mellor, had referred, said that he had indeed, in his patent of 1911, not claimed to raise the refractoriness of the materials, but that object had been in his mind. Some retort material of those days had been highly porous because it contained a matrix of coarse grog, and he had attempted to stop the pores by depositing carbon in them. He had connected up two retorts, stopped the ascension pipe of the one and forced the crude gas of the other retort into the first retort; the retort became so gastight that no gas would escape under a pressure of 24 in. and more. Unfortunately he had not been able to interest fireclay manufacturers sufficiently; but the laboratory cylinders of fireclay, which he exhibited, showed that the particles were really coated with carbon while the pores were filled with a less-firmly bound carbon, and he believed that, by sacrificing a little of the unpurified gas, retorts might be made more gastight *in situ*.

Mr. G. W. Evers, of Stourbridge, speaking next as a manufacturer and also as a member of the committee, said that the statement in the report that a mixture containing 80 per cent. or 81 per cent. of silica had the lowest fusing-point might be misunderstood. But they had ground down their materials exceptionally fine, to 200 mesh, and there was further the question of shrinkage. He had found, like Dr. Mellor, that whole clay began to shrink at 1,000 deg. C.; as silica was being added, shrinkage set in later at 1,150 deg., 1,170 deg., 1,300 deg., and finally at 1,340 deg., when it was all silica. The material with 80 per cent. silica practically did not shrink, and the question was: Which was the better material, that which would not shrink, or that which had some shrinkage and alternatively some expansion?

Steaming in Vertical Retorts.

In the absence of Sir George Beilby, director of H.M. Fuel Research Board, who is abroad, an abstract of his paper on "Steaming in Vertical Retorts" was given by Dr. J. C. Lander. The paper is a report of 57 pages, supplemented by many sheets of diagrams and tables. The introduction is by Sir George, who gives chief credit for the work done in the Fuel Research Section at East Greenwich to Engineer-Commander J. Fraser Shaw, R.N., to Dr. Thomas Gray and his successor, Mr. J. F. King, chief of the laboratories; to Mr. A. Blackie, late of the National Physical Laboratory; and to Mr. J. Skilling and Mr. J. Percival, the carbonising foreman. Steaming coal in vertical retorts at about 900 deg. C. was first tried at Oakbank, Midlothian, for the recovery of ammonia. Reports were published in 1883 and 1885; but the gas industry was not directly interested, and the later introduction of the vertical gas retort had nothing to do with ammonia and steaming. It was a question of high-temperature carbonisation, which required superior refractories and more steel in the settings, making the retort a very costly piece of apparatus, which remains decidedly less foolproof, as Sir George expressed it, than the horizontal settings of earlier years. When the Fuel Research Board was established in 1917, Sir George suggested a resumption of the steaming experiments in which he had taken part at Oakbank; and together with Mr. W. H. Burton he selected the Glover-West retort, in which, with the aid of horizontal combustion chambers, the temperature can be well controlled from top to bottom.

There was no time to describe the plant at the meeting, but we give a few notes. Four retorts were put up in 1919, capable of carbonising 10 tons of coal per day. The gas is supplied to the combustion chambers through a meter; there are no producers built into the setting, and the air is supplied under positive pressure. The four retorts, 21 ft. by 33 in. by 10 in. are arranged in pairs, separate combustion chambers encircling each pair, there being seven chambers in each vertical tier, together with one air-circulating

chamber at the base and two flue-gas chambers in parallel at the top of each pair. From the chambers the flue gases pass through a superimposed special air preheater of Sir George's design, a system of steel pipes of light construction which, with flue gases at 1,100 deg. C., hardly turn red. The air enters the steel tubes at atmospheric temperature and leaves at 390 deg. or less. By closing the chimney damper the pressure in the flues at the top is kept at $\frac{1}{16}$ in., and the same pressure is maintained in each combustion chamber. The water-gas, of 300 B.Th.U., for heating the retorts is supplied from holders at a pressure of 3½ in. In the vertical gas pipe running up the side wall of the setting the gas temperature rises from 51 deg. to 85 deg. as it flows up. Each combustion chamber is supplied through a cock, and a diaphragm is interposed to ensure uniform supply conditions, these conditions being reproduced in apparatus so that the amount of gas passing through any particular diaphragm can be measured. The air for combustion is supplied by a blower at 0·6 in. The temperature in the combustion chamber is 1,250 deg. to 1,300 deg. The steam is generated in a small gas-fired boiler close to the foot of the retorts, and enters the bottom casting by a $\frac{3}{8}$-in. pipe. In the usual working only the steam percentage is varied. The heat losses are determined by sealing the doors at the base of the retort, putting a weighed coal charge in, and measuring the heat required for keeping the combustion chambers at the carbonising temperature of 1,260 deg. for 48 hours. There are the usual provisions for the collection and purification of the gaseous liquid products. The arrangements for measuring the combustion products, especially by weight balances, are unusually elaborate.

The object of the research is to collect data respecting the suitability of various coals for the production of gas, tar, ammonia, coke, oil, smokeless fuel, briquetting and steaming, and the results are compared with those of the Uddingston tests already mentioned and those which Mr. J. E. Blundell, of Macclesfield, and also Mr. John West, published in 1917. As regards the types of coal, Dr. Lander stated, they were working in conjunction also with the Geological Survey. They had already tested 18 bulks of coal, using 0, 5, 12, 20, 30 per cent. of steam by weight of the coal carbonised. The chief coals tested came from Durham, Yorkshire and Lanarkshire. It had been known that steaming could give more gas of 400 B.Th.U. and 450 B.Th.U. They knew now that it also gave more tar and ammonia, at a small sacrifice in the quantity and perhaps the quality of the coke. The greatly increased turnover per retort more than compensated for the skilled labour required. With about 20 per cent. of steam, which seemed to be the economical limit, Mitchell Main (Yorkshire) coal had given 104 therms of gas, equivalent to a total conversion of 33 per cent. of the total potential heat of the coal with gas of 460 B.Th.U.; the yield per ton of coal was 33 therms of gas, 34 lb. of tar, 6 lb. of ammonium sulphate—all these figures being increased yields due to steaming. The gas calorific value without steam was 544 B.Th.U., with steam 460 B.Th.U. The other coals gave less favourable results, except that Lanarkshire coal yielded more tar (40 lb.); the Consett coal seemed little suitable for steaming. Most of the figures were higher than those obtained by the other experimenters.

A lively discussion, very much to the point, followed. Mr. Goulden drew attention to the report and especially to the increase in therms. Mr. Thomas Glover, Norwich, said that the throughput per retort per day, 2½ tons, much exceeded that of horizontal retorts, 25 cwt. to 28 cwt. It was very curious that 5 per cent of steam gave 85 therms against 71 without steam. Perhaps one might question the 10·46 therms supplied to the setting; one would expect the fuel consumption to go up as the gas output went up. But the reactions were not fully understood; moreover, the excess gas was not all water gas, and there was some distillation in the upper part of the retort by the steam and the gas carried upward, though the coal underwent its first distillation in the upper part; that showed that steaming was economical. The ammonia determination was no doubt a very delicate task; but Yorkshire coal had at Greenwich given only 16 lb. of ammonia with 5 per cent. of steam, and 22 lb. (nearly) with 12·4 per cent. of steam. The results did not come up to experience; greater gains had been expected, and if better results had been realised with Lanarkshire coal (39 lb. of ammonia with steam, 32·6 lb. without), why not with Yorkshire coal? Mr. G. Helps, of Nuneaton, regretted the absence of any information as to commercial values of the research.

Mr. Thomas Hardie pointed out that the reports had at the outset emphasised the need of dealing with many different types of coal; that looked as if the selection of coal was more important for the continuous vertical retort than for the horizontal retort, but the tests only showed variations that might be expected also with horizontal retorts. With respect to the Consett coal he showed in detail that the loss of coke was really least in that case, and Consett coal, therefore, would not be unsuitable for steaming. The sticking of the coke in the steamed retorts, mentioned in the report, should not cause trouble if the temperature were maintained, and the frothing of the tar was not necessarily due to the steaming, as they were told. But he was surprised that the high throughput had been possible with steaming.

Speaking next, Professor Cobb particularly welcomed the fact that the Greenwich experiments were to a large extent comparable to his own; but he regretted the absence of chemical balance sheets; practical men were anxious to know the effects of steaming on the sulphur and nitrogen in their particular coal. In ordinary practice steam would visibly escape; the Fuel Board prevented that heat loss by packing the bottom of the retort, and hence they had hardly any condensation in the coke chamber; this and the preheating were not technical conditions, however. Dr. Parker carried these criticisms further. The 20 per cent. steam limit agreed with their own; but they wanted information concerning the effects of steaming in sulphuretted hydrogen, hydrocyanic acid and naphthalene; weight balances might entirely differ from chemical and thermal balances.

Commander Shaw, replying to the discussion, said that they had themselves been surprised to find that less heat had been required for the carbonisation when steam was admitted; and they discussed this point, and the probable influence of the incandescent coke on the carbonisation in their report. Commercial values could not be fixed; the graphs gave some information, but he agreed with Mr. Hardie that the graphs would have been more lucid in general if they had been marked in different colours; the Stationery Office would not do that. He also agreed that the behaviour of the Yorkshire coal which gave more trouble by sticking in the retorts than other coal, had surprised him; the trouble was not serious, however, and would have been avoided if they could have altered the working conditions. Mr. J. F. King, also replying, pointed out that their thermal balances had involved measurements every 3 hours and had been more complete than Dr. Parker had assumed.

Carbonisation in Horizontal Retorts.

The discourse on "Carbonisation in Horizontal Retorts," which Mr. Geoffrey M. Gill, chief engineer to the South Metropolitan Gas Company, illustrated by many slides, was delivered towards the close of the meeting on Tuesday, 11th inst., and was discussed on the following day.

The author's object was to show how, with the existing plant, gas of the highest quality could be made with a maximum yield of therms and the minimum amount of work by keeping plant and tools in the best order. The company, Mr. Gill explained, had introduced a system of inspection which for the 2,900 retorts at Greenwich took the whole time of six inspectors for six weeks; forty-two points were determined and from these the performance of each retort was estimated; the records, circles in red and black, by indicating the amount of red (or black) how much each retort was above (or below) standard, were posted up in each retort house. This inspection, which cost ½d. per ton of coal, enabled them to make repairs in time. These periodical inspections since July, 1919, showed that of each 100*l.* spent in working a retort house, 68*l.* were, on average, wanted for coal, 13*l.* for the coke in the furnaces, 9*l.* for upkeep, 6*l.* for wages and 4*l.* for power, &c. The feed openings of the producers were now closed by cast-iron frames provided with a sand seal; the grate area was enlarged from 1·35 sq. ft. or 1·5 sq. ft. to 3·5 sq. ft. per 20-ft. retort by building two step-grates (instead of one) into the bottom of the producer. As these "basket grates" had been introduced, the coke made had increased and the coke fuel had diminished, mainly because less breeze fell into the pan. The hottest zone above the grate was at 1,200 deg. C.; in the combustion chamber the temperature was 1,280 deg. to 1,325 deg. C.

Each oval retort, 21 in. by 15 in., 20 ft. in length, consisted of three pipes, joined with their square ends. The material contained 77·42 per cent. of silica and 19·66 per cent. of alumina. The average life had by 1919 and 1920 risen to 2,007 days and 1,948 days (from 1,245 days in 1912), and the coal carbonised to 2,288 tons and 2,281 tons, while the average life of 2,000 German retorts, of which 250 remained in use, had been 1,873 days. Each setting comprised twice five retorts, arranged in two vertical tiers, and the method and material of the setting seemed, from Mr. Gill's remarks, to be more important even than the retort material. Between the two tiers and the retorts a non-contracting and non-expanding material with up to 92 per cent. of silica was used, in the parting walls up to 95 per cent. of silica. Insisting upon the need of better materials, Mr. Gill stated that they had made the cross walls from the stage level upward of unburnt clay and grog, mixed in such proportions that slight expansion took place during burning. So far that had answered, whilst formerly shrinkage had taken place between the bricks and round the retorts (up to ¾ in.), leading to failures of the settings. The retort mouthpiece was bolted to an iron socket placed over the end of a retort and built into the front wall. The mouthpieces and the lids were faced by machinery. The average charge for a retort had been increased to about two-thirds of the retort space.

As the charges actually delivered by the Arrol-Foulis and the G. West's scoop machines did fluctuate, the coal drum feeding these machines had been redesigned. The new drum had only three (not nine) radial partitions, and two arc openings, each of 60 deg. A single-roll coal breaker had also been adopted. The new steel augers used for clearing any 5½ in. pipes clogged with tar had a diameter of 5¼ in. and an open centre. When worn down to 4¾ in. they were enlarged again by a smith, the open centre facilitating the work. New stoker tools had been devised, and the Hunter-Barnett pusher machines were provided with levers which automatically lifted the producer door. The machinery worked on both sides of the setting (not on one side only). Combustion chamber temperatures were controlled by wedge pyrometers of the Wedge Optical Instrument Syndicate. At 1,270 deg. C. a charge of 10¼ cwt. could be carbonised in 12 hours, at 1,310 deg. C. in 10 hours, at 1,400 deg. in 8 hours. The dip pipes in the hydraulic mains remained since 1916 unsealed during gas-making, being sealed only when gas making was stopped, on Sundays or at other times; in the unsealed condition the liquor level was ½ in. below the end of the dip pipe. The system avoided the pressure and vacuum oscillations, and had given satisfaction, though it required splitting up the retort house into units of four or five settings to secure full advantage of the arrangement.

The discussion was again most animated, but it was switched at once into a side track, though certainly an important one. Everybody was grateful for the valuable detailed information given. Mr. G. Helps (Nuneaton), who spoke first, called the paper classic and admitted that very few of them would be able to claim anything like Mr. Gill's results. But Mr. Gill was all wrong in insisting upon gas of the highest quality. At the burner's mouth we had 15 per cent. of combustibles and 85 per cent. of air. Why should they send out rich gas? He was sending out gas of 250 B.Th.U. He had started at 350 units, not telling his directors,

and had indeed put "filthy stuff" into the mains. But he called a gas nasty when it was improperly used. By reducing the calories they could give the customer three times as much gas as before for the same money. Pressed about his price, he said he charged 3*s.* 5*d.* a thousand of 250 B.Th.U. gas.

Mr. S. B. Langlands (Glasgow) dissented strongly and deprecated a revolutionary cutting down of the calorific value. The mains, moreover, would not allow of a distribution of three times as much gas. Mr. W. H. Warren, of Beckton, doubted some of Mr. Gill's gains. Small retorts meant many retorts. Their brickwork at Beckton covered 60 per cent. of the setting front., Mr. Gill's 41 per cent. Yet they did as much work at a temperature lower by 100 deg., measuring the temperatures of the combustion chambers by Féry pyrometers. They had converted the West scoop machines into de Brouwer machines. The academic perfection might be very costly.

Mr. W. M. Carr (Ormskirk) criticised Mr. Helps, whom Mr. Harvey Jones rather supported as original and bold, sitting on the fence, however, as Mr. Gill put it afterwards. The Carpenter burner, Mr. Jones remarked, had been the bridge between the illuminating value and the thermal value. Mr. Wesley Whimster (Bath) agreed with Mr. Gill as to the importance of the producer, frequently "bunged," for horizontals, but shared Mr. Warren's doubts as to the apportioning of the cost. Mr. P. S. Hoyte (Plymouth) thought that Mr. Helps might have given them some definite cost figures; had he considered re-canalising and remetering the whole system? Mr. J. G. Tooms, of Christiania, inquired about the use of breeze, successful on the Continent, in producers.

Mr. Gill replied at length, meeting many criticisms, while emphasising that his paper had not been on quality of gas. The 13*l.* on coke in his balance was the coke burnt in the furnace, the difference between the coke made and the coke sold. We cannot go further into particulars here. Mr. Goulden, thanking Mr. Gill, said that the cost of reconstructing a large retort house, as they were doing at Greenwich, on the lines Mr. Gill had described, must be staggering. Horizontal retorts were evidently going to last for some time yet. All distribution systems had been laid down for either 14-candle or 16-candle gas; 450 B.Th.U. and 500 B.Th.U. had answered. To drop down suddenly to a lower calorific value would involve them in endless difficulties.

Liberation of Nitrogen from Coal and Coke.

The next item taken was the Report of the Institution Gas Research Fellowship on "The Liberation of Nitrogen from Coal and Coke as Ammonia," by Mr. A. C. Monkhouse, B.Sc., and Professor J. W. Cobb, C.B.E., B.Sc., which was first introduced by the latter and afterwards more fully explained by Mr. Monkhouse. It has been found that a certain amount of ammonia comes away from the coal by the mere application of heat in an inert atmosphere, but it is possible to obtain more ammonia if the atmosphere is changed to one which assists the process. The work described in the report has been directed towards the further elucidation of this phenomenon using nitrogen as inert, and hydrogen and steam as potentially active agents. The method used was to take Yorkshire bituminous coal, coke it at three definite temperatures—500 deg., 800 deg. and 1,100 deg. C.—so preparing soft, medium and hard cokes, and afterwards to examine the action of nitrogen on the three cokes at three different temperatures, viz., 600 deg., 800 deg. and 1,000 deg. C. Similar experiments were made, using hydrogen instead of nitrogen, and a comparison with steam followed. The report describes the method of preparation of the cokes, the method of analysis, the apparatus employed, and gives the results of the experiments. With the 500-deg. coke using nitrogen, the percentage of nitrogen recovered as ammonia was 9·2 calculated on the original coal, but the proportion recovered with hydrogen was 26·8 per cent. The corresponding figures with 800-deg. coke were 0·2 per cent. and 2 per cent. with nitrogen and hydrogen, respectively, while with 1,100-deg. coke, using steam and hydrogen, the nitrogen liberated as ammonia amounted to 5·7 per cent.; the latter figure was, however, calculated on the nitrogen contents of the coke. The results obtained using nitrogen, hydrogen and steam in succession are also given, and in one experiment with 500-deg. C. coke, using nitrogen and steam only at 800 deg. C., the whole of the nitrogen in the original coal was removed, 21·6 per cent. being driven off during coking, 63 per cent. being obtained from the coke as ammonia, and the remaining 15·4 per cent. being unaccounted for (free nitrogen).

In moving the adoption of the report, the chairman remarked that it was the duty of gas engineers to obtain the maximum quantity of useful products from each ton of coal without concerning themselves too much with market values; the latter, he added, might be left to settle themselves. Discussion was then invited, and Dr. R. Lessing asked that the composition of the ash in the coal should be given in the report as the catalytic action of some of the inorganic constituents would affect the results. Mr. W. W. Townsend, who followed, pointed out that the time element, which was of little consequence in laboratory experiments, was of the utmost importance in works practice. He asked if the authors could say what time would be required for carrying out the reaction on an ordinary working scale. The speaker also pointed out that, if the ammonia yield were increased, more sulphuretted hydrogen would be produced, and he asked to what extent this would offset the advantages of the process.

No other members wishing to speak, the chairman called on the authors to reply, and, in doing so, Professor Cobb agreed that Dr. Lessing's point was a good one, and said the composition of the ash would be added to the report before it was printed in the Transactions. To Mr. Townsend he replied that the time of contact of the gas with the coke had been calculated and was given in the report, and this would allow the conditions to be compared with works practice. He added that some of the experiments had been continued longer than would be possible under working conditions, in order to see if the process could be carried to completion, but the reaction had been found to stop definitely after a certain period. In the report an attempt had been made to show what results would have been obtained in ordinary working periods, and figures were given for contact periods of 6 hours, 12 hours, 24 hours and 48 hours. It was quite true that more sulphuretted hydrogen was obtained when the yield of ammonia was increased, but the speaker thought the time would come when the sulphur in the coal would be used as the source of sulphur in ammonium sulphate.

The chairman then put to the meeting the proposal for the adoption of the report, which was seconded by Mr. S. Glover, and carried.

Tar Distillation and Sulphate of Ammonia Manufacture.

Following this, a communication prepared by the Society of British Gas Industries was read by Alderman F. J. West. The nature of this communication renders an abstract of it of little or no use, since it consists of a collection of descriptions of plants for the distillation of tar and the manufacture of sulphate of ammonia illustrated by general arrangement and sectional drawings reproduced on plates. The tar distillation plants dealt with are by the Chemical Engineering and Wilton's Patent Furnace Company, Limited, Messrs. R. and J. Dempster, Limited, Messrs. W. C. Holmes and Co., Limited, (who make the Hird plant), and Messrs. C. and W. Walker, Limited; the sulphate of ammonia plants are also by the same four firms.

In inviting discussion on the paper, the chairman explained that it formed a corollary to a similar communication dealing with carbonising plant presented to the Institution a year ago. There was, however, a distinct hiatus between carbonising plant and the plant dealt with in the present paper, and he hoped that similar communications covering the intervening ground would be presented.

The first speaker in the discussion, Mr. S. A. Wikner, said the continuous distillation process always appealed to scientists and certainly had the advantage of being quite safe. There had been some, but not many, explosions with pot stills, but there had been innumerable fires as well as accidents in connection with cleaning operations. When financial points were considered alone, however, the continuous process would not bear comparison with the up-to-date type of double-pot still. With the latter it was possible to deal with 120 tons a day with only one attendant, as compared with the figure of 40 tons a day given in the paper for the Wilson still. An outstanding feature of continuous stills, however, was that they were easily repaired. Repairs to the Hird plant were certainly expensive, but they could be carried out easily in a few days. With regard to fuel consumption, the speaker thought the best results must necessarily be obtained when the fire was put directly under the tar, as in the pot still, the waste heat from the fire of the primary still being utilised in the secondary still. It was difficult to get information on this point for continuous stills, but he had found it necessary to use an expensive form of fuel with these in order to get satisfactory results. The Hird plant, he said, was difficult to fire with solid fuel, though it could be done. Some works employed coal gas for tar distillation, and this the speaker regarded as a wasteful process. Breeze, he added, could be burnt under tar stills, and this should be done wherever possible. In conclusion, the speaker questioned to what extent it was desirable for small and medium-sized works to distill their own tar, and expressed the opinion that the work might be done better in one large centre.

The only other speaker in the discussion was Mr. J. P. Leather, who referred to the output of 120 tons a day mentioned by the previous speaker and remarked that, in his own works, this quantity of tar was not available. A man had to be employed in any case, and he could quite well attend to a continuous plant. At his works they employed the Hird type of plant and found it very easy to operate. It took up but little room, was easily watched and temperatures could be recorded and kept correct. With regard to fuel consumption, the speaker said the plant illustrated in the paper was not the most economical. He had first found the temperature of the waste gases very high, and as he was using town gas for heating, it was necessary to effect an improvement. Extra flues had therefore been put round the stills, and this had given greatly increased economy, although the gas consumption was still greater than had been anticipated; it had, however, since been reduced very considerably. Better combustion had been obtained by putting fireclay baffles in the heating tubes, without which some gas had been found to pass through unburnt. In conclusion, he remarked that the arrangement adopted certainly required less labour then would have been necessary if a gas producer employing breeze had been used.

In closing the discussion the chairman remarked that the communication was difficult to discuss, being more in the nature of a book of reference than an ordinary paper. The remarks made had, however, been of a very practical character, and he had no doubt that attention would be given to them by the manufacturers of the plant. The meeting then adjourned.

International Commission on Illumination.

On resuming in the afternoon, the first item taken was a report of the proceedings of the International Commission on Illumination, at meetings held in Paris in July last, by Mr. Robert Watson, the Institution's delegate at the meetings. Mr. Watson said the report was not intended to give rise to debate, but to give an account of the proceedings in Paris. In the gap which had occurred during the war, gas engineers had lost touch with illumination problems, but lighting was still a valuable load to gas companies, and it was highly desirable that attention should be given to the work of the International Commission. He then gave the gist of the report, which dealt with international light standards, definitions being given of luminous flux, illumination and luminous intensity. Papers relating to heterochromatic and physical photometry presented at the Paris meeting were briefly explained, and others dealing with the lighting of factories and schools were similarly treated. Refer-

ence was also made in the report to the subject of automobile lighting, although this is, of course, of little direct interest to gas engineers; the constitution of national committees on technical subjects was also mentioned.

After complimenting the author on his report, the chairman remarked, in moving its adoption, that the interest of gas engineers in matters connected with illumination must not be diminished by the alteration from the illuminating standard to the calorific standard for the sale of gas. If the use of gas for lighting could be extended, the measurement of illumination would be of no less importance than it was formerly. He added that the matter of factory and works lighting must be studied by gas engineers, and mentioned that the Home Office report on this subject was under careful consideration by the Institution. Before putting the report to the meeting for adoption, the chairman invited discussion, and Mr. Langford remarked that the next conference of the International Commission on Illumination would be in America, and also expressed the hope that Mr. Watson would be chosen to represent the Institution there.

Mr. A. Phillips, who represented the American Gas Association, being invited by the chairman to speak on the report, said that, in the United States, the problem of illumination in the gas industry was less acute than it was here. He thought the proportion of open-flame burners used in the United States was greater than in England, but electricity had displaced gas for lighting to a greater extent in the former. Street lighting in the United States, he said, was almost entirely electric, and he had been surprised to see the splendid illumination obtained in this country by means of gas.

Mr. J. P. Leather then seconded the report, which was put to the meeting and adopted unanimously.

Life of Gas Meters.

The report of the Committee on the Life of Gas Meters was then presented by Mr. B. R. Parkinson, who briefly described the various sections, the first of which related to the investigations into the chemical and physical causes of internal corrosion. The constituents considered were hydrocyanic acid, salts of ammonia and carbon bisulphide, oxygen, carbon dioxide and sulphur dioxide, all of which are harmful in the presence of moisture. Correspondence, it is stated, has been carried on with engineers who have found corrosion deposits in mains, services and meters, and laboratory experiments have been continued. In these experiments the conditions of corrosion have been reproduced and attempts made to find a remedy, as well as methods of prevention. With regard to hydrocyanic acid, a method of eliminating this which has given excellent results in the laboratory has been tried. Another section of the report deals with the lubrication of meters by spraying and the effect on meters of introducing oil vapour into the mains. A comparison of notes with a similar committee of the American Gas Association is made, and a reference given to the committee's work in connection with the amendment of the Sales of Gas Act. The principal provision in this is for the testing of meters at 2 in. initial pressure, with a differential of five-tenths, in place of the ½ in. initial pressure prescribed by the Act of 1859. The final section of the report relates to the standardisation of dry meters and their revised denomination. The old-fashioned method of distinguishing meters by the number of lights supplied is dropped, and although size numbers are employed for convenience, the meters will be rated in cubic feet passed per hour. A list of 12 standard sizes giving the capacity per hour, capacity per revolution, revolutions per hour, and sizes of pipe connections, is included. We have already dealt with the report on page 342 *ante*, to which we must refer our readers for further particulars.

The first speaker on the report was Mr. A. W. Glover, who stated that he regarded the inclusion in the report of the conclusions of the American Committee as a very useful feature. He also mentioned that the records of one large undertaking showed that meters should be changed after seven years' use, in order to protect the company from loss. He added that different gases had different effects on the diaphragms. In conclusion, he said that the location of meters so as to avoid extreme variations of temperature, although a very elementary consideration, was certainly worth reiterating.

Mr. D. T. Livesey, who followed, asked if there was any objection to the connections of meters being made with ordinary gas threads. The next speaker, Mr. H. Kendrick, said the present report was of omnibus dimensions, and required very close study, but he thought its lack of suggestions as to wet meters was a serious defect. He expressed the view that the lower quality of gas supplied was largely instrumental in the destruction of both wet and dry meters. Sulphur dioxide, he said, caused much trouble when the protective paint was removed, and he referred to a meter used in Lancashire since 1916, in which the interior drum had been found completely covered with a brown crystalline deposit. Of this deposit, 80 per cent. was mixed ferric oxide and ferric cyanide. The destructive effect was generally regarded as purely chemical, but the speaker thought it was probably electrolytic. All the elements necessary for electrolytic action, he said, were present in a wet meter. He had found cast-iron drum cases dissolved, and many drums were coated with brown crystalline deposit. Chemical action alone, he thought, could not be responsible for this, as the coating was too uniform. The meters attacked, he found, had generally been supplied since 1912, and this, he thought, was due to the fact that the pig-iron from which the castings were made had deteriorated in quality. In conclusion, he referred to an enamel now on the market which was said to be practically indestructible and was being tried for protective purposes.

The discussion was continued by Mr. Thomas Glover, who remarked that he was glad to find the Committee's researches covered an extended field, including the corrosion of plant, mains and services. They had shown that troubles experienced due to certain components of the gas, notably sulphur and cyanogen, had more far-reaching effects than was anticipated. The researches by Mr. Taplay and his latest suggestion for the removal of cyanogen, the speaker thought, were likely to be by no means the least beneficial feature of the inquiry. The gas meter, he pointed out, was the instrument on which the industry depended for its revenue, and was therefore worthy of more attention than it had received in the past. The matter of spraying, he continued, had been referred to in the two previous reports and was originally introduced for the purpose of softening the leather and cleaning the valves; it certainly had that effect. He rather doubted, however, whether the spraying of new meters was beneficial, and thought that excessive spraying with light oils might affect the packing material in the stuffing-boxes. If spraying were done, he thought heavier oils than those used at present might be tried.

The only other speaker, Mr. J. P. Leather, referred to the matter of the amendment of the Sales of Gas Act, and pointed out that the original Act had to be adopted by the justices, or local authorities, within a certain time. If they had not done so, it could not be adopted now. He thought this was peculiar.

The chairman then put the report to the meeting, and it was adopted unanimously. After this had been done, Mr. P. S. Hoyt rose to refer to the process of removing hydrocyanic acid from gas, expressing the hope that particulars of it would be published in the technical press at the earliest possible moment. Its importance to the industry, he said, was such that it was undesirable to wait for the committee's next annual report. The chairman replied that he thought he could promise that this would be done, and he added that experiments on a commercial scale were then in progress in his own works. The chairman then read a telegram from the president of the Société Technique de l'Industrie du Gaz en France, sending wishes for the success of the meeting and expressing regret for his inability to be present. This was received with applause.

The External Corrosion of Mains and Services.

The last paper taken was one by Mr. J. G. Taplay having the title given above. This communication first dealt with the corrosion of iron services in acid ground, and described the investigations made of the corrosion of a high-pressure steel service situated in Shaftesbury-avenue, London. The pipe, which was wrapped in hessian and bitumen, was buried in made ground, which was found to contain acetate of iron and dextro glucose. Bacteriological examination of the ground proved that the corrosion was due to the presence of the bacterium producing acetic-acid fermentation. The corrosion of iron services in alkaline ground, and also in wall plaster was investigated, the corrosive agent in each case being found to be calcium bi-carbonate.

The only speaker in the discussion which followed the reading of the paper, was Mr. J. P. Leather, who said it contained a reference to pipes laid in clay soil becoming softened to such an extent that they could be cut with a knife. The speaker said he had observed this corrosion for forty years, but had usually found ashes in the ground in such cases. Cast-iron pipes, he said, had been found in which the iron had been entirely dissolved out leaving only the carbon behind. For this to happen, however, he thought there must be something exceptional about the pipe, and that a clay soil alone would not be sufficient to account for the action.

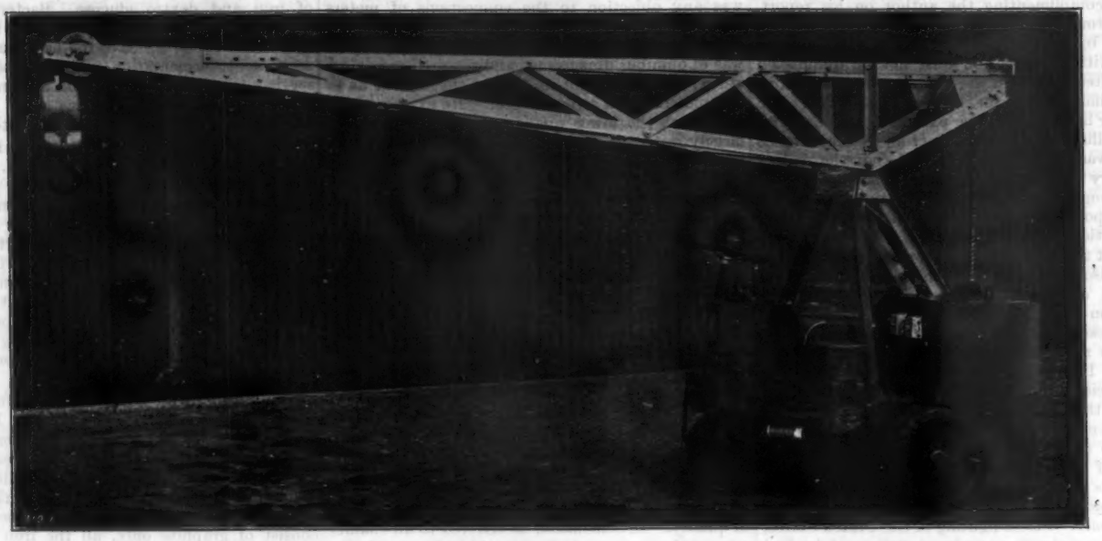
The author, who was then asked to reply, said the phenomenon referred to by Mr. Leather had come within his experience at Beckton in the case of some fairly new pipes. They were, however, laid in made-up ground, largely filled in with clinker, and were also subjected to the action of brackish water. Service pipes had been found to consist of graphite only, all the iron having disappeared, but the corrosive agent was certainly something other than the clay soil. The latter, however, often held a lot of water, and calcium bi-carbonate in such a soil would do the damage mentioned, even without the presence of brackish water.

Invited by the chairman to give some particulars of the method referred to for absorbing cyanogen, Mr. Tapley explained that the Gas Light and Coke Company began experiments on a small scale, using a small tower scrubber passing about 20 cub. ft. a day, which was found to be capable of absorbing 80 times as much hydrocyanic acid as was present in normal coal gas. Consequently a larger plant which could pass from 3,000 cub. ft. to 5,000 cub. ft. a day had been put up at the works, and with this they had succeeded in removing the whole of the acid. Ordinary chalk, obtained from Grays, in Essex, was used in the scrubbers, and he considered the result particularly satisfactory in view of the fact that it had been said that the removal of this constituent did not pay. Mr. J. P. Leather here inquired in what part of the system the scrubber was situated, and Mr. Tapley replied that it was placed on the crude side, all the gas being passed through the chalk purifier. It was proposed to wash down the scrubber occasionally so as to present a fresh surface of the chalk to the action of the gas.

The remaining business of the meeting was of a formal nature, the first item being the selection of a locality for next year's meeting. The chairman proposed that this should be held in London since the Institution had to receive delegates from French Institutions. The proposition was duly seconded, put to the meeting and carried. A vote of thanks to the president, Mr. Thomas Goulden, for his work during the year, was also passed, and similar expressions of thanks were made to the officers of the Institution, the Research Committees, auditors and scrutineers. Mr. Thomas Settle was elected an honorary member, as also were the presidents of the French, Italian and American Gas Associations. The chairman mentioned that Mr. J. Bond had resigned from the National Illumination Committee, and the election of Mr. J. G. Clark in his place was duly confirmed. He also stated that Sir Dugald Clerk had offered to assist in, and to bear the expense of, collating papers and information comparing gas and electricity for lighting and power, the information to be printed in a brochure and distributed to the members. He was sure the members would empower him to accept this offer with thanks. He apologised for the fact that no answer had been previously given to Mr. Livesey's question relating to meter connections, and stated that he had no

15-CWT. ELECTRIC RUN-ABOUT CRANE.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED, ENGINEERS, IPSWICH.



doubt that makers would arrange these for iron pipes if desired. In conclusion, he remarked that as it had been found necessary to close some of the discussions rather cursorily, any written communications which members liked to send would be welcomed and would be recorded in the Transactions. The meeting then terminated.

The South Metropolitan Gas Company.

More than 300 members took part in the excursion to East Greenwich where the works of the South Metropolitan Gas Company were first visited. The company was founded in 1829; its success is largely associated with its three successive chief officers, Mr. Thomas Livesey, his son Sir George Livesey, and Dr. Charles Carpenter, president of the company since 1908, and with their co-partnership policy adopted since 1898. The company does not spell "copartner" with a hyphen. The working men have 36 representatives on the general board, to meet an equal number of officials, and they elect three of the directors. The company own six works, namely, at East Greenwich, Bankside, West Greenwich, Old Kent-road, Rotherhithe and Vauxhall. Of these the East Greenwich works are the largest. Of the coal used 60 per cent. (chiefly Durham) is brought up the Thames in ships of the company.

The East Greenwich works have five retort houses, one of these being a small one of 12 settings, the others containing 45 settings of ten retorts each, the buildings being 485 ft. long and 71 ft. wide. The aggregate daily capacity is 165,000 therms. Farey compound engines draw the gas into the Livesey washers and scrubber and pass it to the purifiers, the sulphur extractors, back to the secondary boxes to remove the sulphuretted hydrogen, to rotary washers, in which anthracene oil absorbs the naphthalene, to the station meters, sunk in large concrete tanks underground, and finally into the 1,500 miles of mains, from 3 in. up to 48 in. in diameter.

The gas is deprived of its carbon disulphide by being passed at 450 deg. C. over glowing balls of fireclay, previously impregnated with nickel chloride and then heated to reduce the nickel; the carbon of the CS_2 is deposited on the nickel as a soot, the sulphur escapes as H_2S and is removed in purifiers. This process of Dr. Carpenter and Mr. Evans was worked out before the war, but the installation had to be postponed.

The gas entering the Beasley calorimeters comes direct from the retort houses, but passes first through miniature purifiers. Of the 400,000 consumers' meters (290,000 for the penny or the shilling slot) 395,000 are now of the dry type. The meter repair department, as well as the central chemical and physical laboratories, are in the Old Kent-road; the chemical manufacture of acids, ammonia, and of tar products and intermediates is conducted at special works in East Greenwich.

Water gas is not made at East Greenwich, there are no carburetters and none but horizontal retorts; but the company is conspicuous for its high-quality gas, of 550 B.Th.U. with 8 per cent. to 10 per cent. of inerts. Visitors were particularly interested in watching the construction of the new settings and in examining the fine collection of specialities exhibited, the neutralised, dry, and pure ammonium sulphate of Mr. E. V. Evans, the metro-burners of Dr. Carpenter and the various lamps, stoves and furnaces. The inverted metro-burners are made in three sizes for 25, 50, 75 candles maximum. A "metro" is provided with a bayonet socket, Bunsen tube, dust cap, an ejector and a thimble-shaped nozzle, perforated below, at the end of which the gas burns. The dust trap is a brass cylinder, constricted below in goblet fashion in such a way that the uprushing air is deflected downward again and cannot deposit dust on the perforated ejector disc which closes the Bunsen orifice. This disc of nickel, about $\frac{1}{4}$ in. diameter, is perforated with two, four or six holes; the cutting and perforating (by steel needles) is so neatly done in little, hand-worked machines, that no burr can be detected. Every burner is tested, and the devices and gauges exhibited testified to the extreme care bestowed upon these appliances, which were repeatedly praised during the meeting. A complimentary luncheon in the Livesey Hall of the company, and a kinema display of gas-making and gas utilisation followed the inspection of the works.

The Fuel Research Station.

These features left little time for the visit to the Fuel Research Station, adjoining the works, where Sir Richard Threlfall and Sir Charles Parsons received members in the absence of Sir George Beilby. We have already spoken of one of the main lines of experiments, steaming in vertical retorts, and we referred last week also to peat investigation. The other chief work on the problem of low-temperature carbonisation is approaching completion, and a report is soon to be issued. Various coals are being tested in the same thorough way as the steamed coal. One hundredweight of each coal is finely crushed and put into shallow pans of iron, about 4 ft. square; a grating of bars of iron divides the pan contents into cubes of 3 in.; the pan is placed into a shallow steel retort, lenticular in section, to be carbonised. The coke cubes obtained are firm and give a smokeless good fire, easily lighted and maintained. At present South African coals are being studied.

Social Events.

The social features of the meeting—which included a luncheon and a reception and dance on the Tuesday, and a luncheon on the Thursday—were thoroughly successful. The speeches, as well as the discussions, bore witness to what is agitating gas engineers. At the first luncheon, given in the Engineers' Club, where Mr. T. Goulden presided, Sir Henry Maybury, K.C.M.G., President of the Institute of Transport, proposed prosperity to the gas industry, for which cheap coal was the first requisite. Mr. D. Milne Watson, M.A., governor of the Gas Light and Coke Company, in responding, said they had to wear down the prejudice against old-fashioned gas engineering in order to enlist the young: they could then get rid of unemployment. He charged the miners with responsibility for the coal dispute, whilst Sir Arthur Duckham, proposing the "Institute of Gas Engineers," held the employers and the Government likewise responsible. Dr. Carpenter, presiding at the Livesey Hall luncheon, infused new spirit into such speeches. Referring as Mr. Goulden had done to the services which the gas industry, under the leadership of Lord Moulton, had rendered to the country, he remarked they had to go on fighting to hold their own, and that required research, development not alone from within, and new methods of doing business. The man not suitable to manage works might be placed in care of a district. Passing to copartnership, Dr. Carpenter added that members might sit next to a working-man director. Mr. Thomas Goulden, in replying to the toast of his health, said that he believed in evolution, not revolution; they had, like all engineers, to contribute to the welfare of mankind and to find out what consumers wanted. Mr. Harry Jones finally proposed the health of Dr. Carpenter, dwelling upon his distinguished work. Direct and indirect allusions to the gas-quality problem were frequent in the speeches.

15-CWT. ELECTRIC RUN-ABOUT CRANE.

There are very few factories in which the desire has not been felt more or less acutely for a power-driven run-about crane, capable of being manœuvred in confined spaces, and able to assist in such work as the loading and unloading of railway trucks and motor lorries, the storage of goods, the erection of machinery, &c. The crane illustrated on this page has been devised by Mr. P. A. Mossay to meet these requirements. The structure carrying the jib is built up on

a roughly circular chassis, which has driving wheels at each side driven by separate motors and steering wheels fore and aft. The jib has a luffing motion only, slewing being provided for by the rotation of the whole machine on the ground. To effect this the steering wheels are turned at right angles to their travelling position, and at the same time the field of one of the motors actuating the driving wheels is reversed so that when current is switched on by the controller, the whole crane rotates on its axis, in either direction as desired.

The crane will lift 15 cwt. working load at a radius of 10 ft., the highest position of the hook at his radius being 12 ft. It is stable in any position without anchorage. It will rotate in a circle of 6 ft. 3 in. in diameter at 2½ r.p.m., and will travel at about 300 ft. per minute. The hoisting speed is 20 ft. per minute. The crane, complete with driver, weighs about 3 tons, and when fully loaded with the jib in any position the maximum load on any wheel does not exceed 1 ton. The machine can be used as a tractor if desired and will haul a load of 3 tons at about 3 m.p.h. Power is supplied from a 20-cell battery of 258 ampere-hours for travelling, hoisting, derricking and slewing, the storage being sufficient for an average day's work.

When the jib is lowered to the horizontal position, the crane will pass under a 7-ft. 6-in. doorway, and as its overall width does not exceed 6 ft. it can be manœuvred in very cramped spaces. The fact that the driver's seat rotates with the work when the crane is slewing, keeps the work always in full view. The method of slewing ensures that there shall be no variation of stability as the load is slewed, and as a result the crane can be built for about half the weight that usually has to be put into a machine for the same service. The absence of any necessity for anchoring or spragging the undercarriage is also a great advantage, as it permits the crane to be traversed when carrying its full load.

The crane is manufactured by Messrs. Ransomes, Sims and Jefferies, Limited, of Ipswich, and the selling agents for it in Great Britain are Messrs. Mossay and Co., Limited, 7, Princes-street, S.W. 1

THE NORDBERG WINDING ENGINE.

THE Nordberg Manufacturing Company, of Milwaukee, Wisconsin, U.S.A., some six years ago, completed a winding engine for a 3,200-ft. double-compartment shaft, which embodies many unusual features. The engine was installed for the "Old Abe" shaft of the Homestake Mining Company, of Lead, South Dakota, U.S.A. At this shaft the ore is hoisted from a number of levels, and like the majority of the ore mines in the Western States, while the hoist is normally operated in balance, it has to be capable of lifting the full load out of balance.

Conditions at the site of the shaft made it impossible to set the winding engine in line with the shaft, which

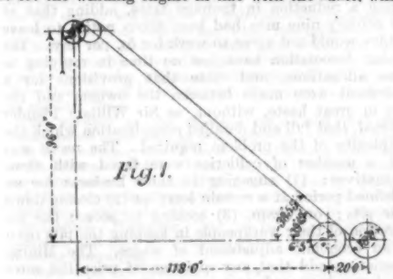


Fig. 1.

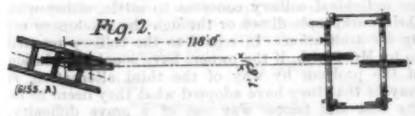
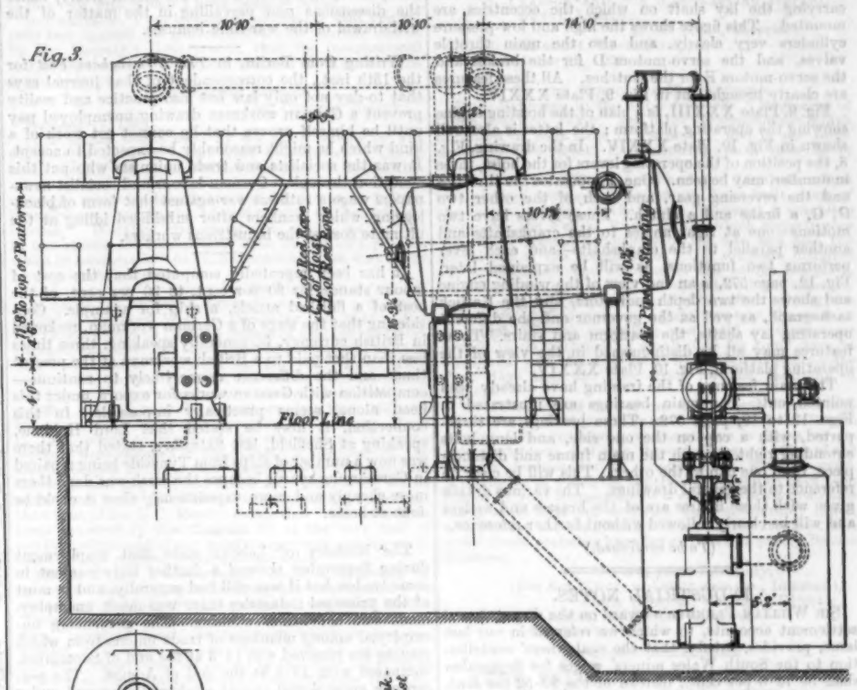
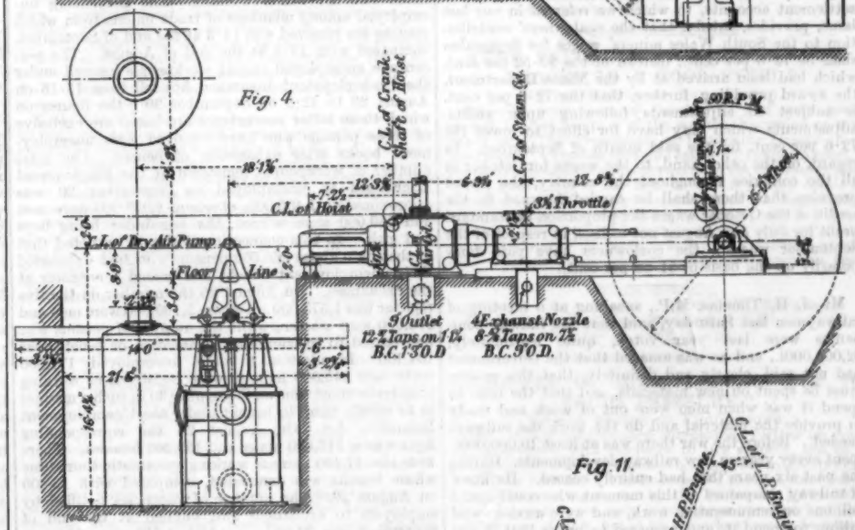


Fig. 2.

had therefore to be arranged as indicated in Figs. 1 and 2, the latter showing the line of the pit shaft set obliquely to the line of haulage. This arrangement necessitated the two hoisting ropes being placed only 18 in. apart, centre to centre. Flat ropes were decided upon, the use of such ropes being very common in the Western mining districts. In this instance this was partly decided upon because it was at one time thought that the hoist would have to be located much nearer to the pit-shaft than the distance shown in Figs. 1 and 2. It is clear that with only 18 in. distance between the rope centres it was not possible to place both reels on one shaft, and this fact was one of the principle reasons for the somewhat unusual design of this winding engine. As the hoisting has to be done from different levels of the shaft each reel had to be loosely mounted on its shaft and held by means of powerful friction clutches so that the ropes could be accurately adjusted for hoisting in balance from any level. Fuel is expensive at Lead and, as it has been found in several other cases that a compound hoist uses practically one-half the amount of steam as a non-condensing hoisting engine, it was decided to build this hoist with compound cylinders and to run it condensing. The size of the engine hoist necessitated the use of servo-motors not only for the clutches,

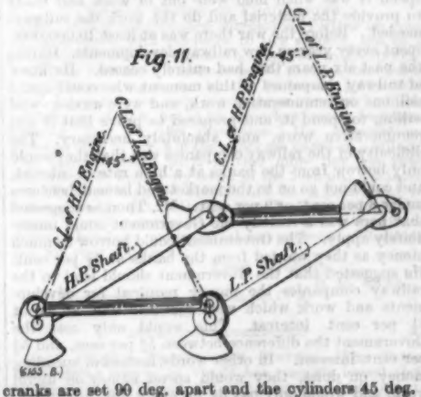




brakes and reversing gear, but also for the throttle. These servo-motors are operated with compressed air from the rock drill system of the mine. The ropes are ⅝ in. thick and 7¼ in. wide, weighing 10 lb. per foot or a total of 32,000 lb. each. The hoist has to lift a net amount of ore 12,000 lb. in a skip weighing 7,500 lb. The boiler pressure is from 150 lb. to 160 lb. to the square inch. The hoist is located at an altitude of 5,400 ft. above sea level.

The engine has two high-pressure cylinders, 28 in. diameter, and two low-pressure cylinders, 52 in. diameter, with a stroke of 42 in. The arrangement is such as to produce one impulse from the steam cylinders for each 45 deg. of a revolution, or eight impulses per revolution. The Nordberg Manufacturing Company has built a number of winding engines on this principle, some of which are of very large size, and it has been found that this type of engine handles more easily than the ordinary twin engine, which is a very important advantage in a hoisting engine. The four-cylinder hoists which this firm have built heretofore have all been on the diagonal type, as illustrated in Fig. 5, Plate XXXII, which shows a winding engine built for the Tamarack Mining Company, for 6,000 ft. depth.

The Homestead engine is illustrated in Figs. 3 and 4, annexed, and Figs. 6 to 10, on Plates XXXII, XXXIII and XXXIV, and Fig. 12, page 572. This engine, as already mentioned, has two shafts with a reel on each. In an engine of the Tamarack type, the cylinders are placed with centre lines at an angle of 90 deg. to each other, while the centre lines of the cranks are 135 deg. = 180 deg. — 45 deg. apart. On the Homestake hoist, which has two crankshafts with a reel on each, the



cranks are set 90 deg. apart and the cylinders 45 deg. apart, Fig. 11, shows in a diagrammatic way the arrangement of crankshafts and cylinders. It will be seen from this figure that the crankshafts are coupled together by means of side rods in much the same manner as the driving axles of a locomotive. The main connecting rods of the engines are coupled to the crank pins in the manner illustrated in Fig. 11.

Figs. 3 and 4, above, give outline drawings of the hoist and condenser, and show their relative positions. Coming now to the drawings in Figs. 7, 8 and 12,

Plate XXXIII and page 572, Fig. 7 shows a side elevation of the hoist and illustrates the construction of the engine frames. The framing consists of the main frames A, which include the bored slides for the crosshead and the main bearing. A large distance-piece B connects the lower ends of the main frames, and a smaller distance-piece C connects the upper ends of the main frames and serves as a support for the bracket carrying the lay shaft on which the eccentrics are mounted. This figure shows the high and low-pressure cylinders very clearly, and also the main throttle valves, and the servo-motors D for the brakes and the servo-motors E for the clutches. All these features are clearly brought out in Fig. 9, Plate XXXIV.

Fig. 8, Plate XXXIII, is a plan of the hoisting engine showing the operating platform; the latter is also well shown in Fig. 10, Plate XXXIV. In the drawing, Fig. 8, the position of the operating levers for the hoist, three in number, may be seen. One, F, operates the throttles and the reversing gear, and each of the other two G, G, a brake and a clutch. These levers have two motions—one at right angles to the crankshafts and another parallel to the crankshafts—and each lever performs two functions, as will be explained later. Fig. 12, page 572, is an end view of the winding engine and shows the two depth indicators, and the Karlick tachograph, as well as the governor and the different operating lay shafts, the platform and stairs. These features may all be distinguished in the view of the operating platform, Fig. 10, Plate XXXIV.

The main features of the framing have already been pointed out. The main bearings are illustrated in Figs. 13 to 19, page 572. These bearings are three-parted, with a cap on the one side, and long bolts extending right through the main frame and distance-piece, from one cap to the other. This will be clear on reference to the general drawings. The various details given with these figures are of the brasses and wedges and will be clearly followed without further reference.

(To be continued.)

INDUSTRIAL NOTES.

Sir William Plender's award on the disputed coal settlement accounts, to which we referred in our last issue, provides, briefly, that the coalowners' contribution to the South Wales miners' wages for September shall be 72·6 per cent., instead of the 97·52 per cent. which had been arrived at by the Mines Department, the award providing, further, that the 72·6 per cent. is subject to adjustments following upon audits, adjustments which may have for effect to lower the 72·6 per cent. for the said month of September. In regard, on the other hand, to the wages for October in all the collieries throughout the country, the award provides that there shall be carried forward to the credit of the October wages the proportion of standard profit for July and August not utilised in respect of the September wages; the coalowners have paid temporarily on the basis of 51·68 per cent.

Mr. J. H. Thomas, M.P., speaking at a meeting of railwaymen last Saturday, said that the railway companies were last year voted, quite legitimately, 52,000,000*l.*, and he was amazed that the Government had not said, clearly and definitely, that this money must be spent on new materials, and that the time to spend it was when men were out of work and ready to provide the material and do the work the railways needed. Before the war there was at least 10,000,000*l.* spent every year on new railway developments. During the past six years that had entirely ceased. He knew of railway companies at this moment who could spend millions on remunerative work, and were anxious and willing to spend it, and prepared to prove that it was remunerative work, and absolutely necessary. The difficulty of the railway companies was that they could only borrow from the banks at a high rate of interest, and could not go on to the market and issue debentures under 8 per cent. or 9 per cent. Mr. Thomas suggested that here was a remedy the Government could immediately apply. The Government could borrow as much money as they wanted from the banks at 5½ per cent. He suggested that the Government should lend to the railway companies the money required for developments and work which were remunerative, at about 5¼ per cent. interest. This would only cost the Government the difference between 5½ per cent. and 5¼ per cent. interest. In other words, instead of spending money on doles, they would spend money on useful work, and would only pay 5*s.* for every 100*l.* advanced.

Mr. John Hill, the secretary of the United Society of Boilermakers and Iron Shipbuilders, also deals in the report for October of this society with Government loans, and says: "Would it be too much for our Premier and his committee of experts to pass a short Act abolishing all interest on national loans, paying back the full amount lent, slowly, but surely, as trade improved, and paying immediately the small sums to poor investors who are entirely dependent on their savings. Would it be too much to demand this small sacrifice of rich men when millions of poor men offered their labours and their lives freely? Such an Act would be no injustice." The only comment we need make on this proposal is this: During the war men in every rank of society offered their lives freely, but practically no one offered his labour freely, hence the dissensions now prevailing in the matter of the withdrawal of the war-time bonuses.

Writing from Berlin, in *The Birmingham Post* for the 13th inst., the correspondent of that journal says that to-day not only law but also practice and reality prevent a German workman drawing unemployed pay until he himself proves that he cannot get work of a kind which he might reasonably be expected to accept. It was the socialists and trade unionists who put this condition through. German labour and socialist newspapers wage a ruthless war against that form of blackleging which hankers after subsidised idling at the ultimate cost of the industrious workers.

It has been repeatedly computed that the cost of labour stands for 80 per cent. to 90 per cent. of the cost of a finished article, a ship for example. Considering that the wage of a German workman, reckoned in British currency, is, generally speaking, three times less than that paid to a British workman at the present time—and the difference seems likely to continue—competition with German works for export, under this head alone, seems practically impossible. In this connection, it may be stated that Lord Haldane, speaking at Sheffield, last Saturday, stated that there was now a number of ships from Tyneside being repaired in German dockyards because the work was done there more cheaply and more expeditiously than it could be done at home.

The Ministry of Labour state that employment during September showed a further improvement in some trades, but it was still bad generally, and in most of the principal industries there was much unemployment and short-time working. The percentage unemployed among members of trade unions from which returns are received was 14·8 at the end of September, compared with 16·3 at the end of August. The percentage unemployed among workpeople insured under the Unemployment Insurance Act fell from 13·15 on August 26 to 12·2 on September 30; the figures on which these latter percentages are based are exclusive of those persons who have removed their unemployment books after exhaustion of benefit. The total number of workpeople registered at the Employment Exchanges as unemployed on September 30 was approximately 1,405,000, of whom 1,078,000 were men and 229,000 were women, the remainder being boys and girls. In this connection it should be noted that at that date about 366,500 persons who had exhausted their unemployment benefit had ceased to register at the exchanges. On August 26 the number on the live register was 1,573,000, of whom 1,190,000 were men and 275,000 were women, while the number of persons who had ceased to register after exhaustion of benefit was 104,100. In addition to those unemployed, 177,000 males and 145,000 females were registered as working systematic short time on September 30 in such a manner as to entitle them to benefit under the Unemployment Insurance Act. On August 26 the corresponding figures were 218,600 males and 189,200 females. There were also 41,400 persons working systematic short time whose benefit was exhausted, compared with 13,600 on August 26. The number of vacancies notified by employers to exchanges and unfilled at the end of September was 21,000, of which 5,250 were for men and 13,500 for women.

Changes in rates of wages reported as having come into operation in September in the industries for which statistics are compiled by the Ministry affected over 2,040,000 workpeople, of whom nearly 1,680,000 sustained decreases, while over 360,000 received increases. The net effect of all the changes was a reduction in weekly full-time wages of over 240,000*l.* The principal groups of workpeople affected by reductions included building trade operatives, whose wages were reduced by ¼*d.* per hour generally in Great Britain in the case of skilled men, while labourers sustained reductions ranging from ¼*d.* to 1¼*d.* per hour; coal miners in all districts except the Yorkshire and East Midland districts (where there were small increases) and Scotland (where there was no change), in the case of whom there were reductions amounting to 2*d.* and 1*d.* per shift for workers over 16 and under 16 years respectively in Lancashire, Cheshire and North Staffordshire, and to 6*d.* and 3*d.* per shift respectively in other districts; and employees of gas and electricity undertakings, whose wages were reduced under national agreements. Other important reductions affected electrical cable makers, jute workers, printers and bookbinders, &c. Since the beginning of 1921 changes in rates of wages reported to the Ministry have resulted in a net reduction of over 3,800,000*l.* in the weekly wages of nearly 6,600,000 workpeople, and a net increase of over 25,000*l.* in the wages of about 150,000 workpeople.

The number of trade disputes involving stoppages of work reported to the Ministry as beginning in September was 57. In addition, 43 disputes which began before September were still in progress at the beginning of that month. The total number of workpeople involved in all disputes in progress at any time in September (including those thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 20,000, as compared with 26,000 in the previous month and 104,000 in September, 1920. The estimated aggregate duration of all disputes during September was nearly 150,000 working days, as compared with over 200,000 days in August, 1921, and with 1,100,000 days in September, 1920. The estimated aggregate duration of all disputes reported as in progress during the first nine months of the present year was approximately 84,000,000 working days. The total number of workpeople involved in these disputes was approximately 1,700,000. In the corresponding period of 1920 nearly 9,500,000 working days were lost owing to disputes in which approximately 780,000 workpeople were involved.

On October 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was about 110 per cent. above that of July, 1914. The corresponding figure for September 1 was 120 per cent.

The Railway Clearing House has announced that a temporary reduction will be made as from November 1 in the railway rates for the transport between places in Great Britain of iron ore and limestone.

The Ministry of Labour have decided that a further period of benefit under the Unemployed Insurance Act (at the rate of 15*s.* per week for men and 12*s.* per week for women), is to commence on November 3, to continue for 16 weeks, or, if necessary, for 22 weeks.

Mr. Herbert Smith, president of the Yorkshire Miners' Association, stated last Monday, at a council meeting of the association, that 12,000 Yorkshire miners were totally unemployed at the present time whilst the majority of those employed were only working short time. He also said that some owners were seeking to break agreements by attempting to obtain a reduction in tonnage rates, adding that at one colliery nine men had been given notice to leave as they would not agree to work for 5*s.* per day. The Mining Association have lost no time in replying to these allegations, and state that provisions for a settlement were made between the owners and the men in great haste, without, as Sir William Plender asserted, that full and detailed consideration which the complexity of the problem required. The result was that a number of collieries were faced with three alternatives: (1) engaging in their business for an undefined period at a certain loss; or (2) closing down their pits; or, again, (3) seeking to secure the co-operation of their workpeople in keeping the pits open by an economic adjustment of wages. The Mining Association add that any question of price list rates has always been and must necessarily remain a matter for individual colliery concerns to settle, either with their workpeople direct or through the machinery set up for arbitration. In regard to the colliery referred to by Mr. Smith, if the owners have sought a solution of the problem by way of the third alternative, it may be that they have adopted what they deem to be the best and fairest way out of a grave difficulty, one which affects owners and men alike.

The Guaranty Trust Company of New York state that the United States imports for September amounted to 180,000,000 dols., as against 363,000,000 dols. for September, 1920. Exports amounted to 325,000,000 dols., which was the lowest total for any month except July, and compared with 372,000,000 dols. for August, 1921, and 605,000,000 dols. for September, 1920. The situation in the steel and iron industry was somewhat improved. The unfilled tonnage of the Steel Corporation on September 30 showed an increase for the first time since July, 1920. The corporation was now working at about 38 per cent. of its full capacity, as against 30 per cent. on September 1. Pig-iron production for September increased for the second consecutive month, the average daily output being 32,850 tons, as against 30,780 tons in August.

A QUICK-ACTING BENCH VICE.

A NEW bench vice of the quick-acting type has been lately introduced by the International Construction Company, Limited, of 56, Kingsway, W.C. 2. This vice is designed by Professor G. E. Cassel, and is of the parallel-jaw type. Only a short length of screw, some 2 in. long, is used, and the movement of the screw in the nut is limited to about a quarter of an inch. A quarter turn or so of the handle is sufficient to lock the jaws in position, while very little more is required to exert a very powerful grip on the work.

In place of the usual screw the movable jaw has fixed to it a plain cylindrical spindle with three longitudinal vee grooves cut in it. In these grooves run three vee-pieces which form fingers extending from a circular sleeve slightly larger than the grooved spindle. The fingers are tapered at their ends, on the outside, and thus form wedges which are pressed into the grooves by a second sleeve bored to a corresponding taper fit. Slight relative movement between these two sleeves causes the fingers to grip the spindle, or to release it as the case may be, this action being independent of the longitudinal position of the fingers in the vee grooves, and consequently of the width of jaw opening and size of the work held. The relative movement is provided by a short length of screw working in a nut in the body behind the fixed jaw. The screw is rigidly fixed to the outer sleeve previously mentioned. It should be stated that a block is interposed between two of the fingers and fixed to the outer sleeve so that when the spindle and fingers are turned by the handle the outer sleeve moves round also. This has the effect of working the screw in the nut, drawing the sleeve up and exerting through the tapers and fingers a grip on the spindle and movable jaw. A small but powerful spring is interposed between the two sleeves so as to tend to keep the wedges apart, thus releasing the grip as soon as the spring is allowed to extend by unscrewing the handle. The vice is very powerful and quick in action, and may be drawn out or closed in very quickly to fit any piece of work.

THE STANDARDISATION OF FAN CAPACITIES.

TO THE EDITOR OF ENGINEERING.

SIR,—On the 11th inst., at the meeting of the Institution of Heating and Ventilating Engineers, I had the pleasure of hearing a paper read on the subject of "The Need of Standardising Fan Capacities at Total or at Static Heads," and of listening to the interesting and instructive debate that followed. One point, however, was not insisted upon, viz., the value of such standardisation for increasing this country's much-needed export business by the help it would give to engineers overseas.

I venture to draw attention to this point because there were suggestions made that all one has to do when designing a system in which the movement of air comes into question, was to prepare the scheme and send it to the fan maker asking him to calculate the resistance of the airways, &c., and to say what fan he advised and the cost of it. It is obvious that time would not admit of such procedure by an engineer overseas who has to send in his tender within a limited period, and it seems plain that export business must therefore be dealt with on sounder lines.

One speaker at the meeting mentioned that there should be no more need to send schemes to the fan-maker than to send diagrams of an electric lighting installation to the dynamo builder. It may be that if standardisation were arrived at, we should find that velocity, quantity and resistance, in air matters, would present no more difficulties than do their counterparts in electrical calculations. However, that is for the engineers to consider, and they are evidently alive to the advisability of doing something.

Those who are interested in export business will be grateful for any step that may be taken to avoid useless correspondence, delay and perhaps losses attendant upon faulty specifications. There is also the risk that the fan may unjustly be condemned through being unsuitable for the work demanded of it.

Yours faithfully,

October 18, 1921. "EXPORTER."

COAL SUBSIDY.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been directed to your leading article of October 7, entitled "Industrial Depression and a Coal Subsidy." You tell your readers that in *The Observer* I have "pretended that cheaper coal is incompatible both with a reasonable return on the capital spent in developing the mines and with a proper standard of living for the miner." Readers of *The Observer* know that I have made no such contention, and that I oppose subsidies on principle. Thus, on July 3, I said, "I believe the case is one in which special measures in the direction of stimulating cheap production by subsidised energy, *pending the restoration of economic energy*, would be justified." Again, in *The Observer* of June 12, I said, "For my own part, I would not hesitate to apply artificial stimulation to manufacturing output by the expedient of temporary coal subsidy, *while taking every possible step to make subsidy unnecessary, as it ought to be.*" In short, the coal subsidy which I propose is purely a temporary expedient, just as I presume Sir Peter Rylands' proposal for a steel subsidy is made. In the economic field it is to be compared to the use of medicine in sickness. Surely one may suggest that quinine is good for a fever without being charged with proposing to feed the British population for an indefinite period on a quinine diet.

On the subject of energy in its permanent aspect I have never ceased to urge in *The Observer* and elsewhere that this should be cheapened scientifically by a number of methods with which I have dealt in detail.

In conclusion, I am interested to observe that you set your face against the general current of opinion, shared by His Majesty's Government, that the international war debts should be cancelled out as a hindrance to the world at large.

Your obedient Servant,

LEO CHIOZZA MONEY.

October 12, 1921.

[The actual words used by Sir L. C. Money in *The Observer* of October 2 last were as follows:—"Cheap coal, the life blood of British industry, is impossible unless we call on the mineowners to work at a loss, and upon the miner to do arduous and dangerous work for a living worse than we should care to offer to a workhouse inmate." Whether this statement, which we quoted in our article, is incompatible with the writer's present claim to have made "no such contention" we may leave our readers to judge.

As bearing on the reason for the high cost of fuel, we may quote the following figures, taken from a diagram published by Lord Weir in December last year:—For the 19 years prior to 1908 the output of coal per operative engaged was never less than 280 tons per annum, and the wages cost never exceeded 6*s.* per ton. From 1908 onwards the output per man has fallen with increasing rapidity and the wages cost per ton has risen even more rapidly, until in 1919 the output was less than 210 tons per man and the wages cost more than 25*s.* per ton. Even in 1915, when so many of the sturdiest of the mine workers were engaged in the defence of the country, the annual output of those who remained was 270 tons, and the wage cost per ton was below 8*s.* Lord Weir, whose opinion on industrial matters is vastly more important than that of Sir L. C. Money, states that "the considerations involved in this diagram lie at the very root of our difficulties and of any possible recovery and improvement in our general industrial situation."

The fact that a writer who "opposes subsidies on principle" can suggest subsidising the coal industry to the extent of 45,000,000*l.* a year, and can think that a "bounty on coal exports is worth practical consideration," involves a self-contradiction which makes one wonder what value he can place upon his principles. But why other industries should be taxed for the support of the coal trade, and especially to accentuate the competition of the foreign manufacturer by paying part of the cost of his fuel for him, are questions which we should like to see answered.

With regard to the last paragraph of the above letter, we need not again comment on the indefensible "*petitio principii*" involved, as it appears to be Sir L. C. Money's standard form of argument. If it would be good business on the part of creditor nations to annul debts owing to them, then every bank in this country would become more prosperous by making a present to its customers of the amount of their overdrafts, and manufacturers would attain wealth by ceasing to send out invoices for goods supplied. If the idea is that the "world at large" would be better by the cancellation of all international debts, then, by the same reasoning, prosperity could be brought to Great Britain by the burning of every ledger in the country, so that all debts would be wiped out and we could start business again with clean slates. The argument, when reduced from airy generalities to concrete instances, is so silly as to carry its own refutation.

What the world needs at the present time is a restoration of confidence in the stability of things, and nothing is more destructive of confidence than the suggestion of any tampering with the obligations of a nation. The British people have justly prided themselves on their high commercial integrity, and our position in the world has been founded on national and individual honesty. Every suggestion that we wish to repudiate debts owing to other nations for goods supplied by them on credit is about the most damaging blow that British prestige and trade could receive, and every genuine Englishman must deplore the weakness of moral fibre which could entertain any such idea.—ED. E.]

"THE YELLOW RIVER BRIDGE CONTRACT."

TO THE EDITOR OF ENGINEERING.

SIR,—Due to my absence from my usual surroundings, I regret I failed to see your issue of October 7 until this week, or I would earlier have asked you to correct statements appearing in a letter signed "Moorebennet" in that issue, relative to the above, and not flattering to British enterprise and effort.

The conditions published by the Chinese Government were that the contract would be awarded to the bidder whose design was adjudged best by an International Commission and premia would be paid to the second and third best designs.

The first place has been awarded to the combination consisting of the Société d'Etudes et de Construction, the Société Belge de Chemins de Fer en Chine, and the Compagnie Générale de Chemins de fer et de Tramways en Chine, with whom my firm are in partnership. Of these three companies the work of getting out the designs and tenders was in the hands of the active company of the group, viz., the Société d'Etudes et de Construction, which is a combination of Messrs. S. Pearson and Son (Contracting Department), Limited, and the Compagnie Belge de Chemins de fer et d'Entreprises.

Two entirely independent designs and tenders were got out, one in Brussels and one in London, the latter design and tender being that which was awarded first place out of the schemes jointly submitted. It may be of interest to your readers generally, and to your correspondent "Moorebennet," to know the part that a British firm actually took in the competition for the Yellow River Bridge contract with success.

Yours faithfully,

S. PEARSON AND SON (CONTRACTING DEPARTMENT), LIMITED,

E. W. MOIR, Director.

10, Victoria-street, Westminster, S.W. 1,

October 17, 1921.

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the letter from the "Engineers of China, Limited, Pekin," and other correspondence which appeared in your issue of October 7, and in the press generally, we think the following facts may be of interest.

Our firm (Sir William Arrol and Co., Limited), whom it is perhaps unnecessary to remark, have built some of the largest bridges in the world, prepared a complete design for the Yellow River Bridge which entirely met the rather special conditions of the site and also the conditions of the specification. Our estimate included the manufacture and erection of the bridge complete, including foundations, and we despatched the same by one of our own engineers to Pekin, after cabling the authorities of his departure. Unfortunately, the steamer on which he was travelling was held in quarantine (owing to an outbreak of small-pox) for some days at Singapore, with the result that he arrived in Pekin some three days after the date fixed for the receiving of tenders.

We endeavoured to get our design and tender considered both through the instrumentality of the British Foreign Office (to whose representative in China we are much indebted), and also through the good office of the Chinese Ambassador in London, but without avail. If the figure at which the contract is alleged to have been placed by your correspondent is correct, then we can now safely state that our estimate was considerably lower, and but for the unfortunate delay to the steamer, this order would probably have been given to a purely British tenderer.

We are, yours faithfully,

(For SIR WILLIAM ARROL AND CO., LIMITED),

JOHN HUNTER, Managing Director.

85, Preston-street, Bridgeton, Glasgow,

October 18, 1921.

"THE PREVENTION OF HARDENING CRACKS IN A TOOL STEEL."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of October 7, you were good enough to give a report of the written discussion on my paper on "The Prevention of Hardening Cracks in a Tool Steel." I notice that you call it a "tungsten steel," which expression by a slip appeared in the advance copies of the paper, but in the final issue it is simply called a "tool steel." The point would be of no importance except for the fact that the condition to which I drew attention in my paper is not associated with only one particular steel. It may, I believe, be brought about over a whole range of carbon and low-tungsten tool steels.

Yours faithfully,

SHIPLEY N. BRAYSHAW.

Mulberry-street, Hulme, Manchester, S.W.,

October 15, 1921.

"STRESSES IN SHIPS' PLATING DUE TO FLUID PRESSURE."

TO THE EDITOR OF ENGINEERING.

SIR,—I had not intended encroaching further on your valuable space with reference to this subject, but as a second letter from Professor Abell appears in ENGINEERING of the 14th inst., I feel compelled to say a final word.

It is interesting to see by the Professor's letter that there is *now only one point* in my paper on which he holds a difference of view, but in his remarks thereon, he brings nothing new to the discussion. His observations directed only to Fig. 6 of the paper are based on a fallacy. The figure referred to is neither more nor less than *diagrammatic*, and in my letter of the 30th ult. I pointed out that the diagram should not have been read to measurement; yet, although the Professor admits his error, he still returns to the matter and attempts to deduce therefrom arithmetical comparisons. Thanking you for your courtesy.

Yours faithfully,

B. C. LAWS.

71, Fenchurch-street, London, E.C. 3,

October 19, 1921.

THE PETTER ENGINEERING SOCIETY.—The Petter Engineering Society of Yeovil has recently issued their syllabus for the season 1921–22, from the 24th inst. to March 20. Nine papers are to be read by well-known engineers, on explosive engines, oil and gas engines, petroleum, flying, and economics.

FEDERATION OF BRITISH INDUSTRIES.—The Grand Council of the Federation held a meeting last Wednesday, when it was decided to recommend to the annual general meeting of members the appointment of Colonel O. C. Armstrong, D.S.O., chairman of Messrs. Greenwood and Batley, to the position of President of the Federation, in succession to Sir W. Peter Rylands.

TWO NEW MINE RESCUE APPARATUS.*

By Professor Henry Briggs, D.Sc., Ph.D., A.R.S.M.

In 1917 the Scientific and Industrial Research Department, at the request of the Home Office, instituted an inquiry into mine rescue work and appliances. The Research Committee,† in their first report (1918), laid down a number of conditions which had to be satisfied by an efficient self-contained rescue apparatus, and, as no such apparatus existed at that time which fulfilled all those requirements, it became necessary to design others that would do so.

The apparatus here described are based on well-known and well-proved principles. They are both regenerative: that is to say, the air exhaled by the lungs is purified, enriched with oxygen and returned to the lungs. The apparatus and the lungs thus form, in each case, a closed circuit, and the lungs serve as a single-acting pump circulating the air round that circuit. The main difference between the apparatus lies in the oxygen supply; in the first the oxygen is derived from the evaporation of enriched liquid air and in the second it is obtained from a cylinder of compressed gas. The head-dress, mouthpiece, nose-clip, chin support, saliva trap, flexible tubes and the valves on the breathing circuit are the same in the two appliances. Both apparatus were designed to enable the wearer to undertake continuous, heavy physical exertion for at least 2 hours; as a matter of fact they can satisfy the respiratory needs of the wearer for 3 hours when suitably charged.

Liquid Air Apparatus.—This apparatus, based upon Blackett's patents of 1910 and 1911, is the result of prolonged experiment by Messrs. G. L. Brown and F. P. Mills, and of the experience gained at the North Midland and the Northumberland and Durham groups of mine rescue stations of which these workers are respectively the chief officer. The liquid "air" employed contains over 60 per cent. oxygen; it is made at the rescue stations and stored and transported in Dewar metallic vacuum vessels holding 50 lb. each.

Fig. 1 (not to scale) is the flow diagram of the apparatus. The portions represented on the diagram below the line X X are hung on the back of the wearer; those above that line are carried in front. The flexible tubes attached to the mouthpiece pass over the shoulders. The general appearance of the apparatus is illustrated by Figs. 2 and 3; they also show the canvas jacket upon which the appliance is supported. In Fig. 3 the breathing bag has been drawn out of the canvas cover in which it is carried. The charge of liquid air is poured through a long-necked funnel, through the orifice B, into the "pack." This vessel consists of a strong metal case E, insulated with magnesite-asbestos F, and having a stout leather cover on the outside. A second, lighter, metal case H, is contained within E, there being an air space G, between the two. H is divided into compartments by a gauze framework (dotted lines), and dry, calcined asbestos wool is rammed into the spaces A, A, A, A. The asbestos wool soaks up the liquid air so completely that, after a working charge has been poured in, the pack may be turned upside-down without any of the liquid air escaping. Air evaporating within the pack passes along the tube D into the space G, and thence through K into the breathing circuit. The space G serves a treble function: First, it enables the air moving through it to gain heat flowing in through F, the rise of temperature thereby produced being sufficient to prevent the inhaled air being too cold and to prevent the freezing-up of the discharge end of K; secondly, G acts as a trap for any liquid which, due to over-filling of the pack, may escape by the tube D, and thirdly, it improves and in some degree regulates the insulation of the pack. In the latter connection it is to be observed that the insulation, while being sufficient to avoid too rapid an evaporation of the air, must allow enough heat to pass to boil off an adequate supply for the period of use of the apparatus. When the pack has been freshly charged the rate of evaporation is high; the volume of cold air circulating in G is at a maximum, and its insulating effect is thus also a maximum. The tendency, therefore, is, at this stage, for the air space to effect a reduction in the excessive ebullition of gas, while towards the end of a "run" when the evaporation is flagging, it is stimulated by an increase in the passage of heat across the air space. In comparison with older designs of pack, the operation of filling is much expedited; only one opening B has to be closed by a blank screw cap after charging. The working charge of 4½ lb. to 5 lb. of liquid air can be put in, and the cap screwed on, in less than a minute.

The breathing circuit mainly consists of solid-drawn brass tubing, 1 in. in diameter. The tubular frame is bent over the shoulders at X X, and extends as a wide collar in front of the chest—a novel feature. From the centre point of this collar hangs the breathing bag L. In the form illustrated in Fig. 1 the bag may be said to consist of two saucer-shaped pieces of rubber joined at their edges. Such a bag cannot be entirely flattened by the suction of the lungs and is very unlikely to be flattened by external pressure; at the same time it has the required distensibility. The idea of making the bag like two saucers set edge to edge is Colonel Blackett's; it may be carried out in different forms; the bag may be circular, oval or of the shape of a rectangle with rounded corners. The capacity of the bag is 6 litres. The air is directed round the circuit by the valves V_1 and V_2. These valves are the best the writer had seen for the purpose. They resemble those formerly used as inspiratory valves for the box respirator, with the important difference that the perforated seats are of stout rubber instead of metal. The valve consists of a disc of thin rubber riveted at its centre to a larger, perforated disc. The valve boxes are also the couplings between the flexible corrugated tubes connected to the mouthpiece and the tubular frame, and the valve seats act as washers in these joints. If a valve is put into place the wrong way up it cannot open, and one's attention is thus immediately directed to the mistake. The resistance of the valve is very low, its slip negligible, and it functions well in any position.

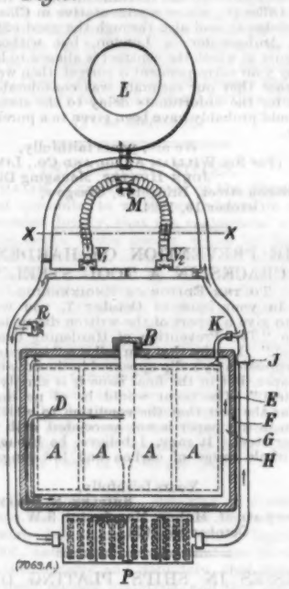
The path of the air through the purifier P is shown by arrows. The purifier, which is placed below the pack, contains a charge of about 1¼ lb. of caustic soda granules held in carriers of perforated metal. The relief valve R is set to blow-off at a pressure of about 3 in. of water column. A low resistance to breathing is a physiological necessity for any rescue apparatus; with the liquid air apparatus, where the relief valve is between the mouth and the purifier, it becomes, in addition, a physical necessity. If the resistance of the purifier exceeds the resistance to opening of the relief valve, the exhaled air will pass out of the latter, the apparatus will become depleted of air, and the wearer will be compelled to reduce his rate of exertion, or, in an extreme case, to cease using the apparatus. For these reasons, care has been taken to bring down the resistance of the circuit, and especially that of the purifier, to a minimum.

During the first part of a "run" evaporation of the liquid in the pack takes place so briskly that, unless the user is working hard, the volume of fresh air supplied exceeds that drawn into the lungs. During this preliminary period the excess of air together with all, or nearly all, the products of respiration exhaust through the relief valve. To prevent excess air flowing from the pack to the relief in the reverse direction, *i.e.*, through the purifier, a mica disc valve J has been inserted. Such a reversed flow would be detrimental in that it would cool the caustic soda and render it chemically inert; later on, therefore, when the purifier is required to come into action, it would be inactive until it had been warmed by the expired air. After the rate of discharge from the pack has become less than the volume demanded by the lungs, the apparatus becomes a true regenerator; an increasing proportion of the expired air passes through the purifier and is re-breathed. Taking 5 lb. of liquid air as a standard charge, and remembering that 1½ lb. is lost in cooling down a pack in falling, a team of five rescue men requires a supply of about 33 lb. for a 2 hours or 2½ hours' spell of work; the apparatus of one team can thus easily be charged from a single 50-lb. container.

The appliance is a pronounced advance on any other liquid air rescue apparatus; it is comfortable to wear, and eminently safe and serviceable. It proves highly satisfactory in extracting CO_2 and in supplying a sufficiency of oxygen to the purified air. Of all existing rescue apparatus it is the easiest to use; there are no cocks to be turned, no valves to be adjusted and no gauges to be read. If 5 lb. of liquid air are poured in, and if the apparatus is airtight, the wearer can be certain that it will serve his needs for well over 2 hours; the only indicator needed is the alarm watch carried by the brigade leader. Charged with 5 lb. of liquid air, the complete apparatus weighs about 35 lb. It is made by Messrs. Guest and Choimes, Rotherham.

Compressed Oxygen Apparatus.—The apparatus which goes by the writer's name was described in the second report of the Mine Rescue Apparatus Research Committee. Since that report was issued the appliance has been improved in detail. Here again we have an apparatus of the closed-circuit or regenerative class (see flow diagram, Fig. 4) in which the expired air after being purified by passing through the caustic canister P is replenished with oxygen at D, and returns, *via* the cooling tube F, and the breathing bag connected at A, to the lungs. The oxygen is stored in the cylinder C, under a pressure of 120 to 150 atmospheres. It passes thence through a reducing valve of special design, which delivers a constant flow of 2 litres of the gas per minute. Such a feed is more than enough for most purposes; any excess blows off by the relief valve R, and in so doing tends to rid the apparatus of any nitrogen in it. A by-pass is fitted whereby a large excess of oxygen may be immediately obtained. The by-pass is necessary as a safeguard against the possible failure of the reducing valve, against the chance—a remote one—of the bag being suddenly squeezed flat, and is useful in occasionally "washing out" the apparatus through the relief valve. The latter operation is to expel nitrogen. It is necessary that the "air" breathed should be as high in oxygen as possible. Nitrogen, whether coming from atmospheric air originally in the apparatus or from the cylinder (commercial oxygen usually contains 2 per cent. of nitrogen and argon), is undesirable, and, if allowed to collect until it seriously reduces the oxygen percentage in the air breathed, may be highly dangerous. The cylinder valve (Fig. 5) has been designed to give the maximum of compactness. It is worked by a key carried by the leader of the rescue team. When the oxygen has been turned on and the cap B screwed on,

Fig. 1.



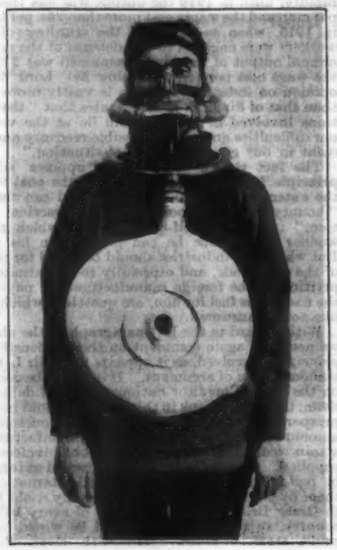


Fig. 2.

Fig. 3.

* Paper read before Section G of the British Association at Edinburgh, on September 14, 1921.

† The members of the committee were, Mr. William Walker, C.B.E. (chairman), Professor J. S. Haldane, LL.D., F.R.S., and the present writer.

the wearer of the apparatus cannot work the valve. There have been, in the past, many accidents due to men purposely or accidentally turning off their oxygen; the best safeguard against such an occurrence is to provide the apparatus with a cylinder valve which cannot be closed by the wearer.

The oxygen feed gear, carried at the man's left side at waist level, is illustrated by Fig. 6 to 10. It is connected to the cylinder at C. The high pressure parts are in gun metal and the low-pressure parts in aluminium. The aluminium is cast on the gun-metal centre, the two metals making a strong and gastight combination. R is the reducing valve, with an aneroid diaphragm; from the reducing valve box the oxygen flows through

Fig. 4. BRIGGS RESCUE APPARATUS, FLOW DIAGRAM.

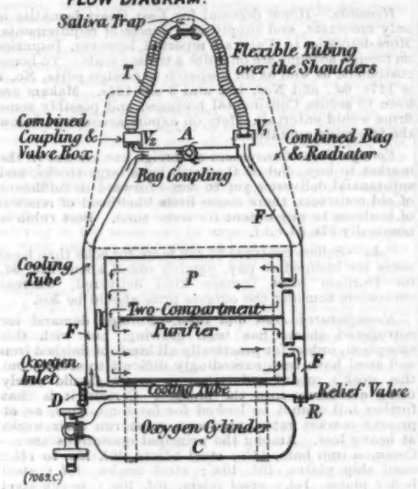
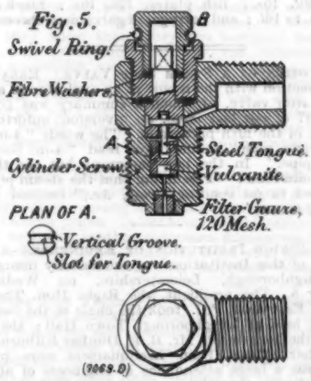


Fig. 5.



a resistance in the passage r. The resistance consists of a tight pad of cotton wool. This diffused type of resistance is preferable to that of a fine orifice, first because it is not apt to be choked by foreign particles; secondly because it can be easily adjusted and thirdly because, if the resistance be constant, the law connecting pressure in R and volume discharged is nearly linear instead of being parabolic. There are two connections to the double, edge-reading gauge G; the first is direct to the high-pressure oxygen supply and the second to the reducing valve box R. There are two pointers and scales to correspond (see plan); they register respectively the cylinder pressure and the pressure in R; but since the pressure in R is almost directly as the flow of gas through r, it becomes possible to graduate the second scale in litres of gaseous flow per minute. The wearer is thus furnished with a flow-gauge of a simple and robust kind which enables him to read the rate of supply of oxygen at any moment. The reducing valve is set to give, during work, a constant flow of 2 litres per minute. The by-pass (B, L_1, V_1) which enables an excess supply of oxygen to be obtained, independently of the reducing valve, is operated by pressure of the wearer's thumb on the balloon-cloth diaphragm B. On releasing the pressure the by-pass automatically closes. This arrangement is preferable to a screw valve. The oxygen from the feed gear passes through the nozzle D and a short piece of rubber pressure tubing to the breathing circuit. The relief valve (R, Fig. 4) functions automatically when the pressure in the circuit rises to 3 in. water gauge, or it can be opened by hand.

The breathing bag, which is on the man's shoulders, is bellows-shaped; the outer side is a flat sheet of chemically-blackened brass which serves three purposes: First, it acts as a radiator; secondly, it gives protection against damage, and thirdly by its weight it ensures a positive pressure within the circuit, so that any slight leakage is outward, not inward. When there is a large leakage it is not possible to keep the bag distended. By curving the strong metal tubular frame (which is also the breathing circuit) over the bag space, the flattening of the bag by contact with the mine roof is made unlikely.

The purifier (P, Fig. 4) is in two compartments. Into each compartment there slides a light tin carrier open at the top and ends. The ends of a carrier are covered with gauze. A pair of carriers are filled and pushed into their respective compartments; the lid of the purifier (left-hand end, Fig. 4) is then soldered on and the canister is ready for use. The caustic soda which abstracts the CO_2 from the expired air is in the form of granules which are supported, in each carrier, by thin wire gauze trays or partitions. Several arrangements of gauze

BRIGGS RESCUE APPARATUS; OXYGEN FEED GEAR AND GAUGES.

Fig. 6. SECTION X.X.

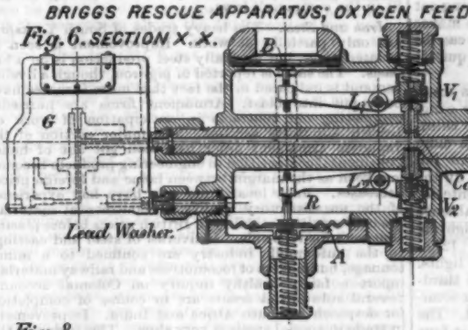


Fig. 7. PART SECTION Y.Y.

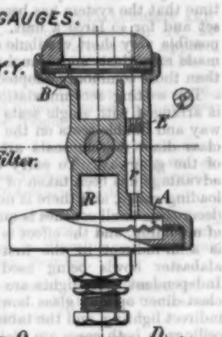


Fig. 8.

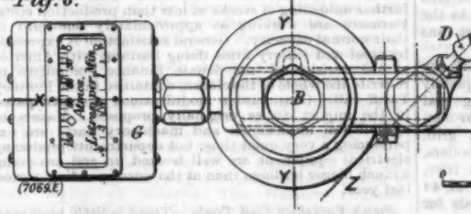


Fig. 9. SECTION Z.Z.

Fig. 10. PLAN OF LEVER L_1

FIG. 10.

have been found suitable; a good one, illustrated in the second report of the Research Committee, consists in placing in a carrier, one above the other, a set of 12 gauze rectangles, cut to fit the carrier, and stamped between dies so that each has received hexagonal depressions arranged like the cells of a honeycomb. A few—not too many—granules are put into each "cell" or depression. The standard charge is 3 lb. of caustic soda; 2 lb. will, however, purify the air during a 2-hours' spell of continual walking at 4 miles per hour sufficiently to keep the CO_2 proportion well below 2 per cent. For use in a hot place it is advisable to employ a charge of 4 lb. of soda; this keeps the inspired air dry as well as pure, and dry air is more rapidly cooled in the tubes and breathing bag than damp air.

The makers of the apparatus (the Mining Engineering Company, Limited, Moorfields, Sheffield) supply two kinds of purifier; the first, a sealed canister, ready for emergency purposes, is intended to be used once only, the other is for practice and training, and can be cleaned and refilled with ease at a rescue station. The apparatus, fully charged, weighs about 36 lb. The photograph, Fig. 10, gives the general appearance of the apparatus when being worn; it also shows the head-dress, mouthpiece and noseclip which have been adopted for both apparatus. The skull-cap is of skeleton form having large spaces for ventilation. A strip of cane is sown into the cap and runs from front to back; it forms some protection against a blow on the head. Further protective covering may be used as desired. As Fig. 10 indicates, provision has been made for an electric head lamp—a form which is certain to come into general use at British rescue stations in the next few years. The nose-clip, of screw pattern, is held to check-plates suspended from the cap; it is of a kind not easy to displace. The rubber mouthpiece is also clipped to the check-plates; it is larger than usual to reduce the chance of a man sucking in air round it, and it is furnished with thicker teeth lugs than has been common in the past. Thick lugs compel the teeth to remain open; the wearer may thus have firm hold of his mouthpiece while preserving sufficient opening between the rows of teeth to keep down the resistance to breathing. A shaped strip of rubber cloth or canvass passes under the chin, the ends being caught to the cheek-plates; the man is thus prevented from dropping his jaw far enough to breathe over or under the mouthpiece. The straps holding the chin support are threaded through the metal cheek-plates in such a way that when they are in place the wearer cannot remove either mouthpiece or nose-clip. The saliva trap is carried in front of the chin; it has a discharge valve at the base; the arrangement inside resembles that of a non-spillable ink bottle to preclude the chance of saliva running back into the mouth.

RAILWAY BRIDGE FOR AMSTERDAM.—The Commercial Secretary to H.M. Legation at the Hague reports that the Dutch Railway Authorities have issued a specification for the building of a new railway bridge at Amsterdam, tenders for which are to be presented by November 14. Further information can be obtained from the Department of Overseas Trade, 35, Old Queen-street, S.W. 1.

EAST LONDON COLLEGE.—The Registrar announces that a course of seven lectures will be given in the evenings of the Michaelmas term by Engineer-Commander B. W. Knott, R.N., Superintendent of the Admiralty Engineering Laboratory, West Drayton, on "Diesel and Semi-Diesel Oil Engines, the Present Position of the Heavy Oil Engine, and the Problems involved in its further Development." The course will commence on Thursday evening, October 27, at 6 p.m., and will be continued on the succeeding Thursdays. Further particulars can be obtained from the Registrar, Mile End-road, E. 1.

NEW DYNAMO AND MOTOR WORKS AT BEESTON.—We are informed that new works, built for Messrs. Ingleby and Co., Limited, dynamo and motor manufacturers, at Old-lane, Beeston, Leeds, on a site approximately 10 acres in area, were formally opened on the 11th inst., by the Lord Mayor of Leeds. The works comprise two buildings, the larger of which is of steel construction and contains the offices and a large machine shop, while the other includes a tool shop, winding department and stores. Provision has, however, been made for future extensions, ample land being available for the purpose. Messrs. Ingleby, it may be mentioned, commenced business in premises situated in Elland-road, Leeds, in 1908, and manufactured a large number of electric motors for Government factories during the war. The new works are capable of turning out motors ranging from ½ b.h.p. to 200 b.h.p., for all industrial purposes.

LONDON–LEEDS DINING-CAR TRAIN.

A new dining-car train has just been put into service on the Great Northern Railway for use between London and Leeds. It is used for the 10.10 a.m. ex-King's Cross and the 5.30 p.m. ex-Leeds. The train possesses many unusual features. It consists of a first-class carriage brake, first-class dining car, kitchen and pantry car, third-class dining car and third-class brake—five coaches in all. These run on six bogies only, the train being arranged on the articulated system which has been used on the Great Northern Railway for several years. This is, however, the first time that the system has been adopted for a dining-car set and for so large a unit. The arrangement makes possible very short vestibule connections which can be made more dust- and draught-proof and much quieter than those commonly adopted.

The seating accommodation of the first-class diner is arranged with single seats on one side of the gangway and double seats on the other, while in the third-class diner double seats are provided on both sides of the gangway. To carry out this arrangement full advantage has been taken of the width allowed by the loading gauge, and there is no cramping. The interior decoration of all coaches is quite plain, with an absence of moulding, and the effect is excellent. Main lighting is semi-indirect in the first-class dining car, 12-in. alabaster bowls being used for the ceiling lights. Independent table lights are also used. In the third-class diner opaque glass bowls are used for the semi-indirect lighting, and the table lights are omitted. The ceilings in both cases are plain white. Extractor fans are fitted in the roof in each case, in addition to the usual torpedo ventilators, but the usual bracket fans are dispensed with.

The most novel feature of the train is that the whole of the cooking arrangements are completely electrical. We think we are correct in saying that in this respect the train is unique. The kitchen contains a water boiler of 11 gallons capacity, grill, steaming oven, roasting oven, vegetable boilers, steaming pans, hot plates, hot cupboards, fish frier, kettles, &c. There is also a hot water tank of 44 gallons' capacity. The kitchen can furnish meals for 78 persons at one sitting, and some 105 dinners have been cooked and served on one trip. Pilot lamps are provided in the kitchen to indicate when any cooking unit is switched on or off, and the whole lay-out is very neat and convenient. One very clear advantage of the electrical equipment is that the kitchen is much cooler and the atmosphere better than would be the case with a corresponding gas equipment.

The electrical energy is obtained from two dynamos of 6-kw. capacity, each fitted with pole charges. These machines are of Messrs. Stone's make, and are belt-driven from the axles in the well-known manner adopted by the firm in connection with their electric lighting equipments. The dynamos work in conjunction with a battery of 80 cells which are carried in two boxes below the underframes. The weight of the battery is 1,880 lb. Automatic switch gear provides against the overcharging of the battery and controls the switching in and out of the dynamo as it reaches or falls below generating speed. When the battery is fully charged any excess current available is switched to the hot water storage tank. The water in the tank is also heated at terminal stations by plugging on to the station supply. The result of the arrangement is a very plentiful supply of hot water without it being necessary to carry generating plant to heat it, so that weight is saved. The plug connection for this terminal heating is interlocked with a valve on the vacuum brake pipe so that, while the plug is in, a vacuum cannot be created and the brakes released.

The whole of the electrical apparatus for this interesting installation was supplied by Messrs. J. Stone and Co., Limited, of Deptford. This firm also supplied the lighting equipment. The cooking ranges, boilers, &c., were supplied by the Jackson Electric Stove Company. The whole train has been constructed at the company's Doncaster works, to the designs and under the personal supervision of Mr. H. N. Gresley, chief mechanical engineer, to whom is due the credit of the various departures from normal practice which the set embodies.

Electric Welding of Cast-Iron and Steel.—The main reports brought before the meeting of the Technical Commission for Foundry Practice of the Verein Deutscher Eisengiesserecen, which was held at München last month, under the presidency of Dr. Ing. S. Werner, of Düsseldorf, were papers by Mr. W. Neese and by Mr. L. Trenheit, on the "Electric Welding of Cast-Iron and Cast Steel," giving particulars of the strength tests of the welds. The welding systems tested were those of Bernardos (arc with one carbon electrode) and Slawianoff (metallic rod as electrode); in both cases direct-current dynamos are used, the particular constructions of which were referred to. The welding metal was a Swedish charcoal iron or a soft mild steel.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Cutler's Feast Cancelled.—Although invitations had been sent out and arrangements were well advanced, the action of the Master Cutler in cancelling the Cutlers' feast has met with general approval. Both the Duke of York and Mr. Austen Chamberlain felt unable to attend owing to prevalent unemployment and distress. This ancient banquet has several times been omitted owing to trade depression locally and domestic causes. The official record of the Cutlers' Company shows that in 1756 the feast had to be postponed for a fortnight owing to the proposal of rioters to dine with the Master Cutler at the top table and make any alterations they thought fit in the company's laws.

Iron and Steel.—The heavy trades of South Yorkshire are only partially at work. Improvement is seen in isolated cases, but generally steel production is on a low basis. The same is reported of pig-iron, though a livelier demand is indicated in the fact that more furnaces have been put into blast. Armament firms are hurriedly completing old contracts in anticipation of work on British Admiralty account. The major portion of the Japanese armament order has been got out of hand. Continental competition in engineering products becomes less keen as the margin between home and foreign prices decreases. Many local firms who have had experience of the unsatisfactory quality of Continental materials are only awaiting stability in British prices before placing contracts for renewals. Deliveries of steel and castings to the automobile industry are confined to a minor tonnage, but makers of locomotives and railway materials report a fairly healthy inquiry on Colonial account. Several substantial orders are in course of completion for despatch to South Africa and India. Improvement in trade in special steels is very slow. This is due to the further unloading of stocks at less than production costs. Furnaces are working at approximately one-third of their normal capacity. General satisfaction is expressed by steel and cutlery firms doing business with America at the decision of the Senate Finance Committee to re-write the whole of the clauses contained in the Fordney Tariff Bill. Considerable modifications are anticipated in the import duties originally proposed. Makers of agricultural implements and machinery parts are experiencing a very quiet time, but departments producing electrical equipment are well booked up and are doing a much bigger business than at the corresponding period last year.

South Yorkshire Coal Trade.—There is little buoyancy in any section of the trade. All qualities are difficult to market. This state of affairs has resulted in decreased output, and, so far as manufacturing fuel is concerned, a general weakness in prices. Stocks of inferior quality fuels are accumulating at pits. Increased deliveries of gas fuels are going to inland works, due to larger consumption for lighting purposes. Householders appear to be unwilling to prepare for the winter. Merchants anticipate difficulty later on in meeting demands, should there be a rush to place orders. Cokes are still weak, with a slight improvement in foundry sorts. Quotations:—Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house coal, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 32*s.* to 33*s.*; Derbyshire small nuts, 29*s.* to 30*s.*; Yorkshire hards, 31*s.* 6*d.* to 32*s.* 6*d.*; Derbyshire hards, 30*s.* 6*d.* to 31*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 16*s.* to 17*s.*; smalls, 5*s.* to 10*s.*

Public Works in Irak.—An intimation has been received that the Director of Public Works, Baghdad, will be glad to receive catalogues and price lists from British firms exporting building and engineering material and machinery. These should be sent for forwarding, to the Department of Overseas Trade, 35, Old Queen-street, S.W. 1.

The Institution of Automobile Engineers.—The Institution of Automobile Engineers, planning well ahead, has adopted a new procedure for its programme of papers for the winter of 1922–23. The idea evolved is that the papers should follow along the same line, a theme being suggested to which all papers will be related, from a point of view decided upon by the Publications Committee. The subject for the session will be the relationship of motor traction in all forms to road construction and maintenance. We understand contributions are expected dealing with this subject with reference to railless trolley traction, roadless traction, impact of wheels on road surfaces, suspension, weight reduction, &c. The sphere and scope of the steam lorry, and the electric vehicle, will also be dealt with both from the makers' and user's point of view.

Keighley Association of Engineers.—The Keighley Association of Engineers opened its winter session with a lecture on October 8, the author being Mr. W. M. Selvey, on "The Heat Balance of an Electric Power Station." The programme for this year includes monthly meetings up to and including March, with the exception of the date in January which is allotted to the annual dinner. The Association has adopted an interesting method of stimulating practical contributions, by arranging an essay competition among members, with prizes of 5*l.*, 3*l.* and 2*l.* for the best papers sent in on "The Manufacture of Four-jaw Independent Lathe Chucks, 18 in. in diam." Each paper must detail the best method of making patterns, of moulding, machining and assembling for a batch of 12 chucks. A drawing of the chuck is provided. The competition is open till December 9.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—A reduction of practically 20 per cent. in railway carriage of ironstone and limestone has apparently had no effect on the values of Cleveland pig-iron. The little No. 3 G.M.B. that is being produced is readily taken up at 120*s.*—the figure that has ruled for some time past for home consumption—and No. 1, which is even more scarce, is put at 125*s.* Export quotations for these commodities are 5*s.* above home rates, but there is hardly any inquiry from abroad. Inferior grades of Cleveland iron are plentiful, and are offered freely at makers' fixed minimum figures of 112*s.* 6*d.* for No. 4 forge, and mottled, and 110*s.* for white iron.

Hematite.—Home demand for East Coast hematite is only moderate, and supply is in excess of requirements. More deliveries to Wales are reported, however. Inquiries on foreign account are on quite a trifling scale. To home customers, as well as for despatch to foreign ports, No. 1 is 127*s.* 6*d.*, and Nos. 1, 2 and 3 are 125*s.* Makers are keen to secure Continental business, and possibly some firms would entertain offers on export account at below the foregoing quotations.

Foreign Ore.—Consumers of foreign ore are not in the market to buy, and as they still have large stocks, and substantial deliveries yet to come forward in fulfilment of old contracts, there seems little likelihood of renewal of business to any extent for some time. Best rubio is nominally 27*s.* 6*d.* c.i.f.

Coke.—Sellers continue to ask more for coke than local users are inclined to pay, naming round about 32*s.* 6*d.* for Durham blast furnace kind delivered, whereas consumers consider the outside price should be 30*s.*

Manufactured Iron and Steel.—Foreign demand for corrugated sheets has been growing, but with this exception, orders for practically all kinds of finished iron and steel have been exceedingly difficult to secure, but this week's record reductions in prices should surely bring customers into the market. Certain it is that further fall cannot be looked for for some time, as, at present market rates, producers must run their works at heavy loss. Among the principal quotations are:—Common iron bars, 14*l.*; steel billets, 10*l.* 10*s.* to 11*l.*; steel ship plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel boiler plates, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fish plates, 15*l.* 10*s.*; black sheets, 15*l.* 10*s.* to 16*l.*; and corrugated galvanised sheets, 19*l.*

Explosion of a Steam Stop Valve: Erratum.—In connection with the report of an explosion of a steam engine stop valve, of which a summary was given on page 537 of our last issue, an inversion unfortunately appears in the fifth paragraph. The words "4-in. solid bore drawn pipe" should have read "4-in. bore solid drawn pipe." In the last paragraph but one the first line should read: "Presuming that the steam pipe was subjected to no bending stress, &c.," instead of "to bending stress."

The Junior Institution of Engineers.—A Local Section of this Institution was successfully inaugurated at Loughborough, Leicestershire, on Wednesday, October 5. The president, the Right Hon. The Lord Weir of Eastwood, P.C., took the chair at the inaugural meeting held at Loughborough Town Hall; the chairman of the Institution, Mr. B. E. Dunbar Kilburn, M.A., and other officers from headquarters were present. There was a large attendance of engineers of all ages. The resolution that the section be established was put by the chairman and carried unanimously. Lord Weir then inducted Mr. H. Schofield, M.B.E. (principal of Loughborough Technical College) as its first chairman. The new section will have its headquarters at the college, a meeting room and equipment having generously been provided by the governors. Persons resident in the district desiring further information should apply to the Local Hon. Secretary, Mr. G. Mavor, The College, Loughborough, Leicester.

Etching Agent for Chrome Steels and Tungsten Steels.—Last year K. Honda and T. Murakami recommended an alkaline solution of ferric potassium cyanide as etching agent for steels containing chrome and tungsten. They assumed the existence in chrome steel of three compound carbides, consisting of Cr_4C and of varying numbers of molecules of Fe_3C, viz., 18 in the α carbide, 9 in the β and 1 in the γ carbide; these compounds were coloured differently by the cold or hot reagent. The same etching agent was further to colour the tungsten carbide Fe_2W brown or blue in high-speed steels containing more than 12 per cent. of tungsten. Dr. Ing. K. Daeves, testing these reactions in the Bismarckhütte, Upper Silesia (*Stahl und Eisen*, September 8, last) recommends for the etching solution the mixing of 100 grammes of water with 10 grammes of caustic soda and 20 grammes of ferric potassium cyanide; the solution is apt to decompose, especially when hot, and the specimen should be immersed for 15 seconds or 20 seconds in the cold or hot solution. The steels tried contained up to 2·2 per cent. of carbon, 11·5 per cent. of chromium and 19 per cent. of tungsten. Daeves did not confirm all the observations of the Japanese investigators. In particular he did not find the solution to be a special indicator of the presence of the carbide Fe_2W. But he found the reagent useful for making sure that the limit of the solubility of the carbon in the eutectic had not been exceeded.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—There has been very little change in the state of trade in general throughout the country during the past few weeks. Employment is very bad, as there is little demand for material of any sort. All trades are suffering, and with so many thousands of workers idle there is not much money available for anything beyond the actual necessities of life. Prices of most commodities have been coming down, and that is the first step towards better trade. Although conditions show no change there certainly prevails a more optimistic spirit, and the outlook in several directions seems brighter.

Scottish Steel Trade.—In the Scottish steel trade there is not much business passing, and conditions are still so bad that a kind of day-to-day existence is all too general. Orders are not easily picked up, as the difference between the Continental and the home prices is appreciable from the buyers' point of view. The cost of production continues very high, and is not coming down fast enough to enable the home article to be put anywhere near that of the foreign producer, but in anticipation of a further fall and to stimulate business the Scottish steelmakers resolved, at a meeting here, on Monday of this week, again to cut prices. Boiler plates were reduced 60*s.* per ton, ship plates and angles 30*s.* per ton, and blooms 20*s.* per ton. At the prices now named it is very doubtful if the makers have any margin of profit left, and it is generally agreed by all—except perhaps the actual worker—that wages and all on-cost charges must come down considerably before any activity in the trade can be expected. Labour has got to work hand in hand with capital, and the sooner the worker recognises the fact that half a loaf is better than no bread at all, the sooner will we get back to active conditions in our works. The policy of holding out for a high standard of, say, 4*l.* per week and only getting two or three days' employment per week, bringing him in 30*s.* to 40*s.*, is of little use to the worker when by accepting a standard of, say, 3*l.* per week, he could get a full week's work. Principle is involved perhaps, but if we are to regain our old position in the commercial world all must be prepared to make some sacrifice. There are many buyers with business to give out, but they cannot afford to enter the market until prices are easier, and the steel-makers have now cut profit out of their calculations in the hope of securing more orders to save completely closing down their establishments. A goodly number of inquiries are going around again, but local prices are still little inducement, and while producers are free to fix export business, at their own figures, they know that every ton accepted means a definite loss. For home delivery the following are to-day's quotations, and in each instance they are about 50 per cent. under the figures quoted at the beginning of the year:—Boiler plates, 16*l.* per ton; ship plates, 12*l.* 10*s.* per ton; angles, 12*l.* per ton; blooms, 12*l.* per ton; rounds, squares and flats, 12*l.* 10*s.* per ton, all net at Glasgow stations and subject to the usual extras, &c.

Black Sheets Reduced.—The Scottish Black Sheet Makers' Association held a meeting in Glasgow yesterday (Tuesday) when, among other matters discussed, was that of current prices. After some consideration it was decided to make another reduction amounting to 30*s.* per ton. The basis price of ¼-in. black steel sheets will now be 13*l.* 15*s.* per ton, net, delivered Glasgow or equal.

Malleable Iron Trade.—No improvement falls to be recorded in the malleable iron trade of the West of Scotland this week, and conditions are almost unaltered. Orders are so scarce that part of the plant is usually quite sufficient to overtake all the business, and even that part is not being kept running for the full week. When the price for "crown" bars was reduced lately to 14*l.* per ton it was thought that an increase in demand might follow, but so far the response on the part of buyers has been rather disappointing.

Scottish Pig-Iron Trade.—Business in the Scottish pig-iron industry is not very encouraging, and even the lower prices now prevailing have failed to induce consumers to fill up their stocks. There are 18 furnaces now in blast in Scotland, but only a portion of the output is being taken up. Local buyers continue to keep out of the market and are somewhat averse to committing themselves so long as the general industrial depression prevails, or until the outlook becomes at least a little brighter. Export business is very quiet also.

Institution of Engineers and Shipbuilders in Scotland.—The opening meeting for the session of the Institution of Engineers and Shipbuilders in Scotland took place last night in the Institute headquarters, in Elmbank-crescent, Glasgow. Mr. Harold E. Yarrow, C.B.E., the new president, delivered his first address, and in which he dealt at some length with the recent developments in design and construction of high-speed vessels. He maintained that much of the progress was due to scientific and industrial research, and said that he knew of no form of expenditure which a Government might sanction that would ultimately yield a better return than money spent in encouraging research. Mr. A. D. Bruce read a paper on "Some Factors Limiting the Power of Diesel Engines."

THE INSTITUTION OF GAS ENGINEERS—ADDENDUM.—In our article last week, on Recording Gas Calorimeters, the name of one speaker was not given in the first column and second paragraph of page 547. The speaker was Mr. J. B. Leather, of Burnley. Lower down in the same column a misprint was overlooked: a calorimeter of the Boyd pattern should read Boys pattern.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The only bright spot in the coal trade is the fact that the contentions of the South Wales coalowners in respect to their wages liability for September and October have been upheld by Sir William Plender, independent chairman of the National Coal Board. In the dispute between the owners and the Mines Department with respect to the wages liability of the former for September, Sir William has fixed that liability at 68 per cent., as compared with the Mines Department's figure of 97 per cent., which means about 2*s.* 6*d.* per ton less for the coal owners. In connection with the October wages, Sir William has decided that the July profits, which were absorbed in August, cannot again be taken into account for the October wages, and thus the percentage above the 1915 standard has been, fixed at 79·03, which is 27·35 per cent. more than the owners' offer, but 32·79 per cent. less than what the workmen calculated they were entitled to. The Midi Railways of France has placed orders with four exporting firms for 50,000 tons of large at 25*s.* f.o.b., 50,000 tons of through at 19*s.* 6*d.* f.o.b., and 50,000 tons of patent fuel at 26*s.* f.o.b., delivery over the whole of next year. Average export prices in September showed a further reduction. Large coal shipped from Cardiff averaged 36*s.* 4*d.* per ton f.o.b., against 43*s.* 6*d.* in August, throughs 24*s.* 8*d.* against 32*s.* 6*d.*, and smalls 16*s.* 10*d.* against 21*s.* 3*d.*, while large exported from Swansea averaged 34*s.*, compared with 40*s.* 7*d.* in August, throughs 25*s.* 3*d.* against 30*s.* 7*d.*, and small 21*s.* 6*d.* against 24*s.* 6*d.* Though many collieries are on stop or working short time the quantity of large coal available is in excess of the demand. Sellers, however, refuse further to modify their quotations, which are on the basis of 30*s.* for best Admiralty large and best dry large, and 27*s.* 6*d.* for best Monmouthshires. Smalls of practically all classes are scarce as a result of the numerous pit stoppages, and for the best qualities 19*s.* is commanded, with ordinaries round 18*s.* and good drys 15*s.* Many sellers refuse to sell small without large. The question of the reduction in railway rates and dock charges is being considered by traders and the railway and dock companies.

Shipping Failures.—Two of the leading South Wales shipping companies are in serious financial difficulties, and both propose the formation of new companies. The first is the Western Counties Shipping Company, Limited, with an ordinary share capital of 2,250,000*l.*, and the other the Maindy Shipping Company, Limited, with a share capital of 200,000*l.* The Western Counties Company, which owns 15 steamers of 94,000 tons deadweight, propose to wind-up the present company and to form a new company with a capital of 450,000*l.*, in shares of 4*s.* each. They state that a foreign Government has offered to take, if required, up to 65 per cent. of the capital of the new company. The Government mentioned is that of Czecho-Slavonika, and it is proposed to buy the ships of the old company. The Maindy Company are in difficulties because their bankers have intimated that they can no longer carry the overdraft of about 280,000*l.* This company owns 7 steamers of about 29,000 tons, and it is proposed to form a new company with a capital of 100,000*l.* in shares of 10*s.* each. Whether the shareholders in the two unfortunate companies subscribe to the proposed new concerns remains to be seen.

UNIVERSAL BOX SPANNER.—A modification of the usual form of box spanner has been brought out by Messrs. W. Crockett and Sons, Limited, 64, Darnley-street, Glasgow, and should prove useful in many awkward positions. The feature of this spanner is that the box head is connected with the shank by a universal joint, which allows the latter to be canted to clear projections, &c., so that the tommy bar used may be turned without striking other parts. The device is a variation of the principle underlying the use of a bent tommy bar, which, on occasions, may be set to clear obstructions. In the device under notice the allowance is provided in the spanner itself instead of the bar. The end of the spanner is provided with holes for a bar, and is also hexagon-shaped, and to Whitworth standard, so that a standard spanner may be employed if desired instead of a bar. The spanner is made in stock sizes from ½ in. to ¾ in.

GREASE CUP FILLER.—Messrs. Trier Brothers, Limited, 36, Victoria-street, Westminster, S.W. 1, have recently brought out a device intended to facilitate the filling of grease lubricators, &c., without soiling the hands. This is especially intended for use with 7-lb. tins such as are used with Stauffers' lubricant, and are provided with a sealed opening in the bottom, or a suitable receptacle for permanent use to be filled from casks, &c. The device is called a grease "extruder," and consists of a top and base coupled together above and below the 7-lb. tin to be used, by bolts hinged to lugs in the base and fitted with knurled nuts engaging with forked ends of the top. The top consists of a bridge piece which serves to support a vertical screw which is plunged in the grease to the bottom of the tin. This screw is fitted with a bevel operated by a small crank handle and bevelled pinion. The screw carries a nut taking the form of a leather-packed piston the diameter of the tin. As the handle is turned this piston is forced down upon the grease, which is by this means squeezed out of the hole in the bottom of the tin into the base. From the latter it emerges through a spout from which syringes, lubricators, &c., can be filled. In addition to avoiding soiling the hands the device has the advantage of keeping the grease free from grit and dust which is so often in tins which frequently have to be opened.

NOTICES OF MEETINGS.

THE INSTITUTE OF TRANSPORT.—Friday, October 21, at 5 p.m., at the Royal Society of Arts, John-street, Adelphi, a meeting for Graduates and Students will be held, when Mr. M. Salt will deliver a lecture on "Water Transport—Coastwise Shipping of the United Kingdom." Sir H. P. Maybury, K.C.M.G., will be in the chair.

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Monday, October 24, visit to the glass-bottle works of Messrs. Bagley and Co., Limited, Knottingley, leaving Keighley (M.R.) at 12.5 p.m.

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—Monday, October 24, at 7.30 p.m., in the Mappin Hall, Department of Applied Science, Sheffield. Sir Robert A. Hadfield, D.Met., F.R.S., will deliver an Address. This meeting will take the place of the meeting on Tuesday, October 25, and is to be regarded as the monthly meeting, members being at liberty to introduce friends.

THE INSTITUTION OF CIVIL ENGINEERS (YORKSHIRE ASSOCIATION).—Monday, October 24, at 7.30 p.m., at the Hotel Metropole, Leeds, Professor G. F. Charnock, M.Inst.C.E., will read his Presidential Address.

THE INSTITUTE OF MARINE ENGINEERS, INCORPORATED.—Tuesday, October 25, at 6.30 p.m., "Modern American Methods in Winning and Preparing Coal," by Mr. J. H. Anderson, Member.

THE INSTITUTE OF INDUSTRIAL ADMINISTRATION.—Tuesday, October 25, at 7 p.m. "Limits of Centralisation in Industrial Administration."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday, October 27, at 7.45 p.m., at Caxton Hall, Westminster, when the president (Colonel E. Kitson Clark) will deliver his Presidential Address. The chair will be taken by Mr. W. Pickersgill, C.B.E., retiring president.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 28, at 8 p.m., at Caxton Hall. "Water Gas Manufacture," by Mr. F. Colin Sutton (Member).

PUBLIC WORKS, ROADS AND TRANSPORT CONGRESS.—The preliminary programme of this congress has now been issued. The congress will be opened in London on November 18, and will continue until the 25th, when a number of papers will be read and discussed. Simultaneously, and in connection with the congress, there will be a Public Works, Roads and Transport Exhibition at the Royal Agricultural Hall, Islington. Further information can be obtained from the Exhibition Offices, 13, Victoria-street, London, S.W. 1.

THE PETROLEUM PROBLEM.—Addressing a meeting of the London Chamber of Commerce, in Cannon-street, last Monday afternoon, on the Petroleum Problem, Mr. A. Beeby Thompson, M.I.Mech.E., arrived at the conclusion that the oil position of the Empire is less precarious than is usually suspected. Various arguments pointed to that conclusion. American and other estimates had prophesied an exhaustion of natural oil within seventeen years; but those estimates were based on a period of unexampled commercial prosperity on the one hand and on the isolation of Russian and Rumanian petroleum on the other. America produced 62 per cent. of the world's oil output (5,500,000,000 barrels), and the British Empire 2 per cent. But America had developed 4,500 sq. miles of oil territory, the Empire 70 sq. miles. Pioneer petroleum work had been done by Alfred Stuart, who sunk the discovery well at Grozny, and by other British engineers and business men all over the world, even in Alaska and Spitzbergen. British capital controlled 15 per cent. of the oil output of the world. The potential output of American fields might be 6,740,000,000 barrels; Burmah now produced 8,000,000, Trinidad 3,000,000, Egypt 1,500,000, Borneo 1,000,000 per annum. Many fields still awaited prospecting; Palestine presented possibilities of no mean order, the foothills of the Himalayas fringing Bengal, East Assam, Kashmir, Afghanistan, Baluchistan, would not long remain neglected; the promising areas of Mesopotamia were certainly very large. There was another important feature. Most of the American oil—though not that of California and of the Gulf States—came from the oldest palæozoic strata; all British oilfields were located in recent tertiary or cretaceous formations, and these latter had everywhere proved far more prolific than the old strata. If the old strata in general yielded 2,000 barrels to 10,000 barrels per acre, the tertiary and tertiary-mesozoic fields gave 30,000 barrels to 60,000 barrels. Most of the spectacular wells were associated with these recent formations, to which 60 per cent. of the world's production up to date could be ascribed. Then there was the extraction-ratio. It was believed that from 50 per cent. to 75 per cent. of the oil remained unabstracted by methods now in use, and the oil and gas resources of the Empire had not been spent lavishly as those of America. Thus Mr. Thomson looked forward to further pleasant surprises in oil discoveries. But he pleaded for unrestricted facilities in development; he deprecated the partitioning of the Mesopotamian fields and the actual official oil policy which could only lead to reprisals, particularly as we remained largely dependent upon America for plant.

COMPOUND WINDING ENGINE FOR THE HOMESTAKE MINING COMPANY.

CONSTRUCTED BY THE NORDBERG MANUFACTURING COMPANY, MILWAUKEE, WIS., U.S.A.

(*For Description, see Page 565.*)

Fig. 12.

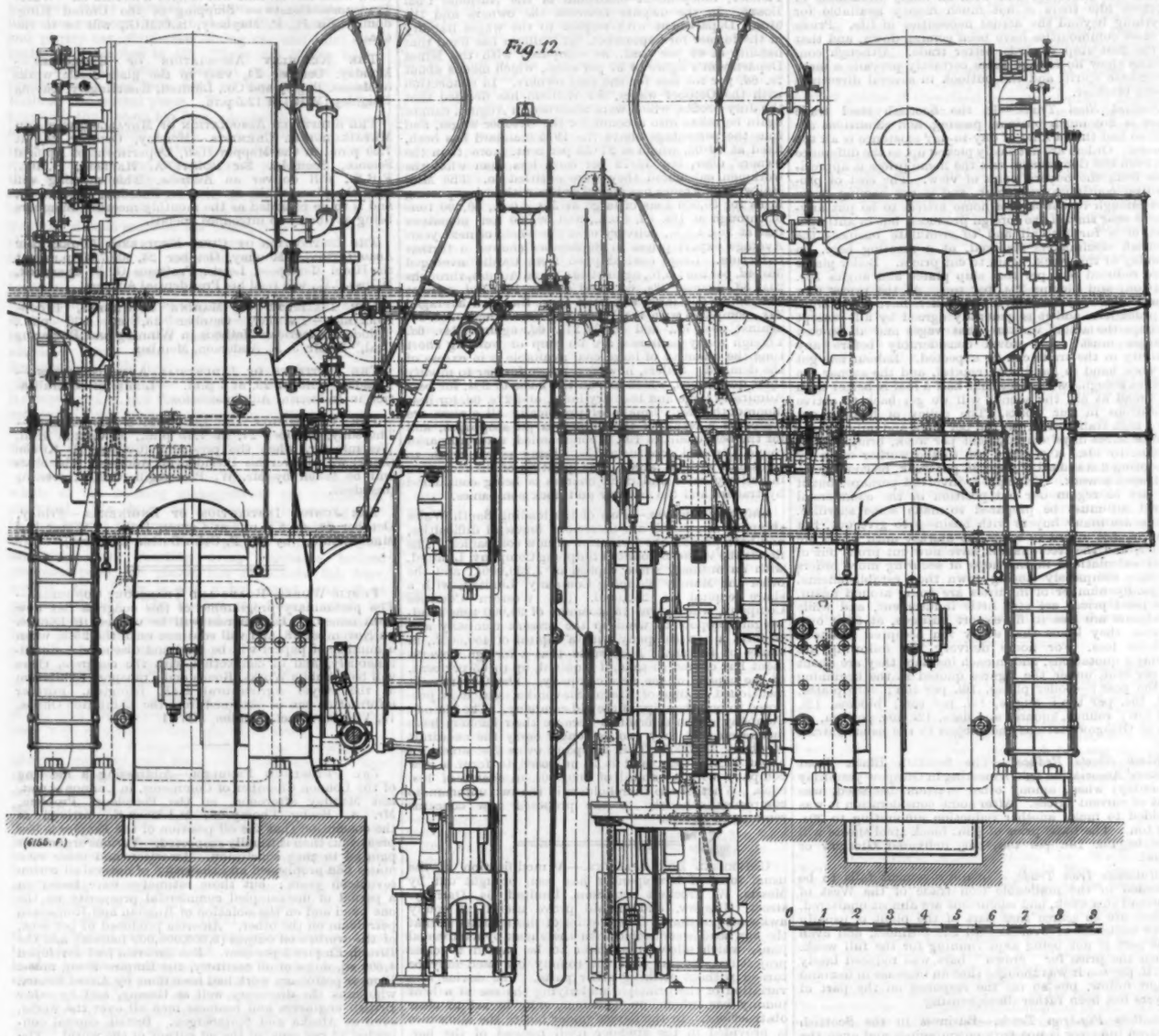


Fig. 13.

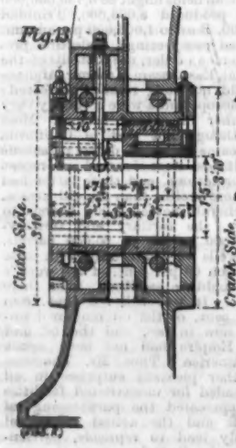
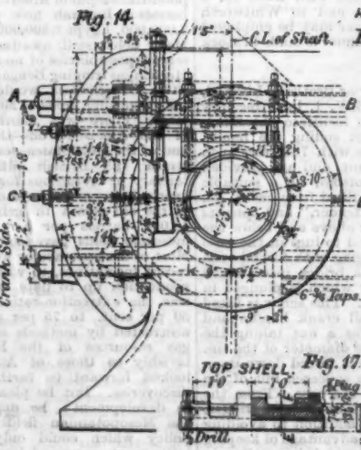
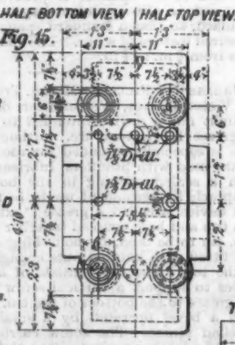


Fig. 14.



HALF BOTTOM VIEW | HALF TOP VIEW.

Fig. 15.



SECTION C.D.

Fig. 16.

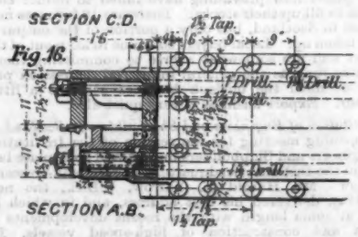
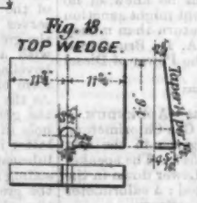
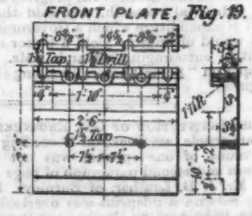


Fig. 17.

Fig. 18.



FRONT PLATE. Fig. 19.



COMPOUND WINDING ENGINES.

CONSTRUCTED BY THE NORDBERG MANUFACTURING COMPANY, MILWAUKEE, WIS., U.S.A.

(*For Description, see Page* 565.)

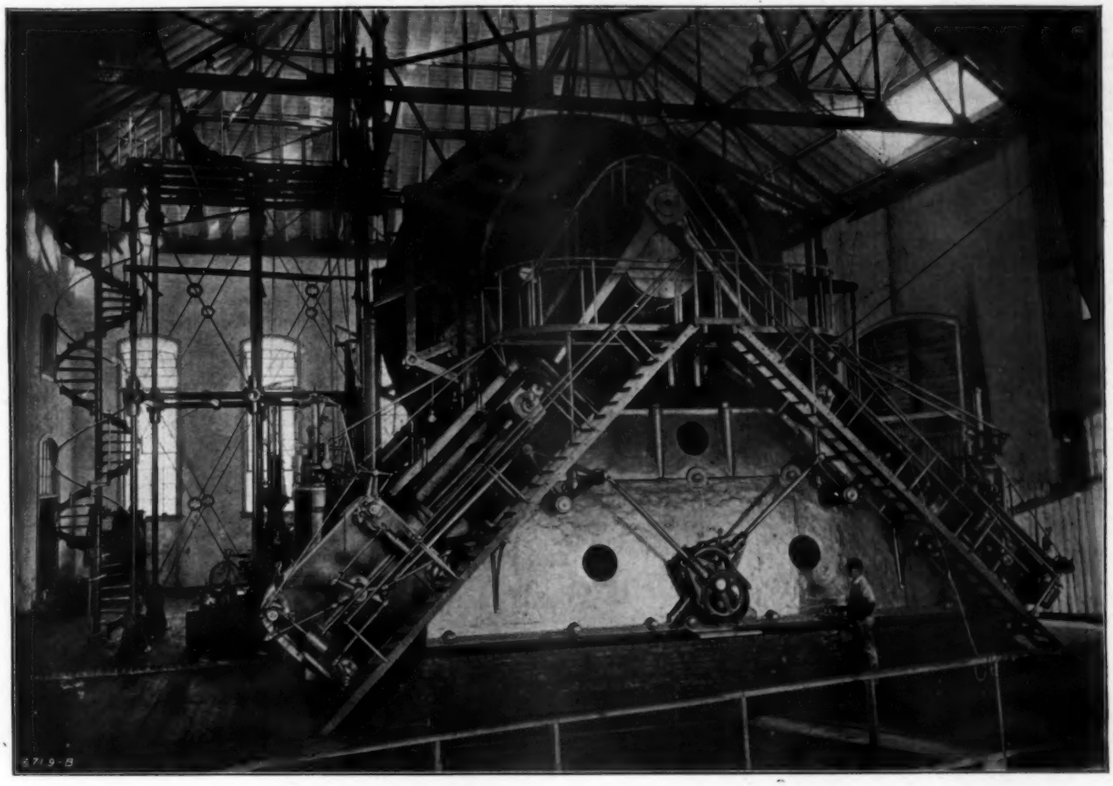


Fig. 5. Diagonal Winding Engine for the Tamarack Mining Company.

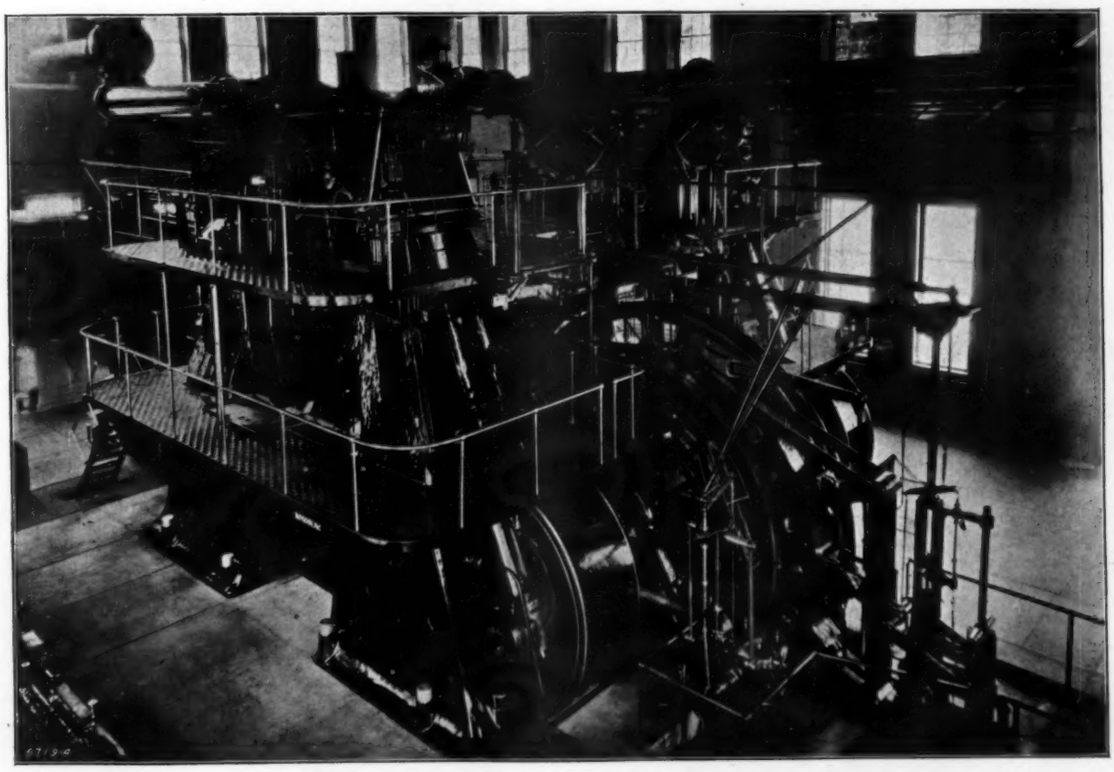


Fig. 6. Winding Engine for the Homestake Mining Company.

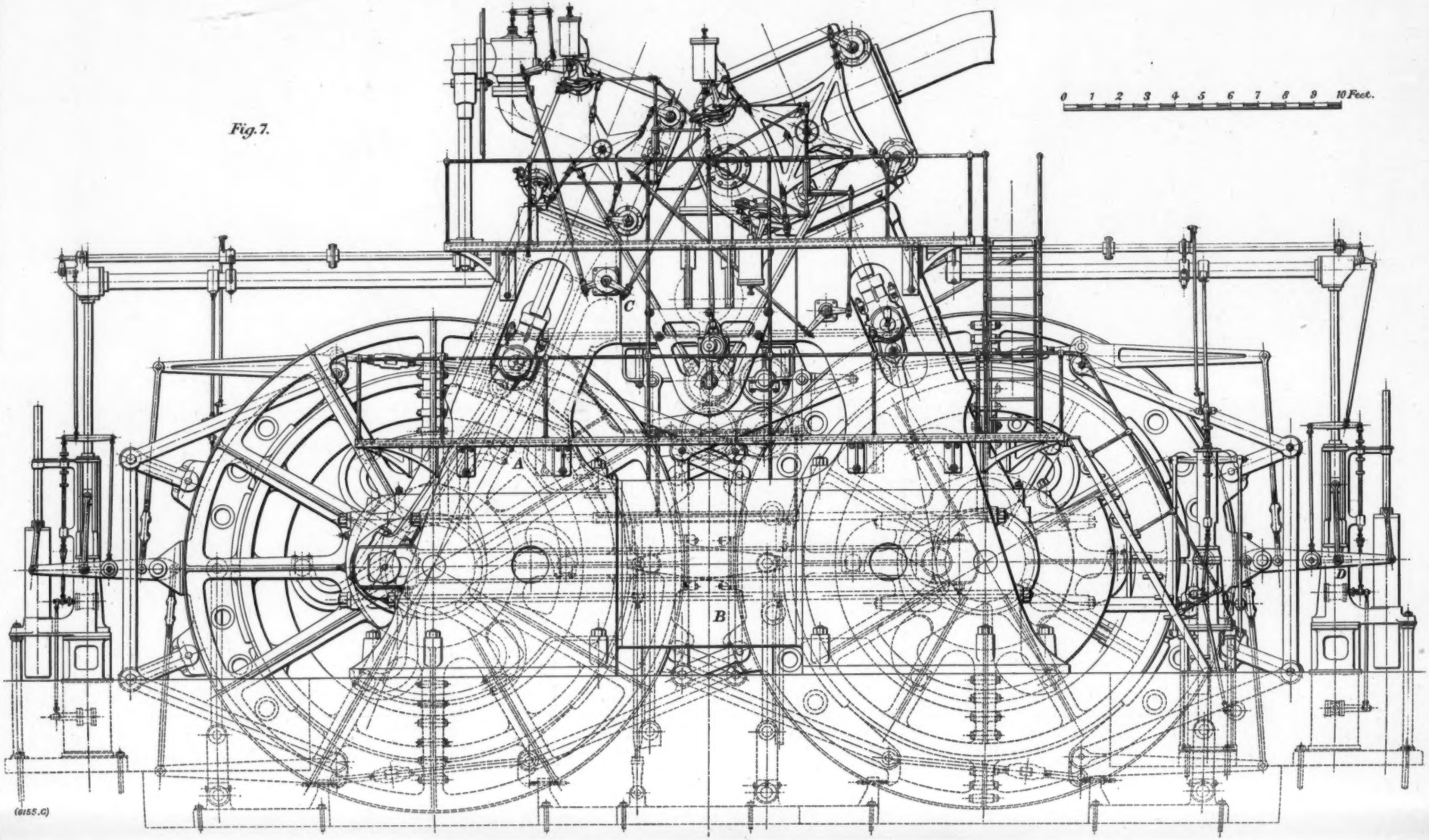
(*To face page* 564.)

COMPOUND WINDING ENGINE FOR THE HOMESTAKE MINING COMPANY.

CONSTRUCTED BY THE NORDBERG MANUFACTURING COMPANY, MILWAUKEE, WIS., U.S.A.

(*For Description, see Page 565.*)

Fig. 7.



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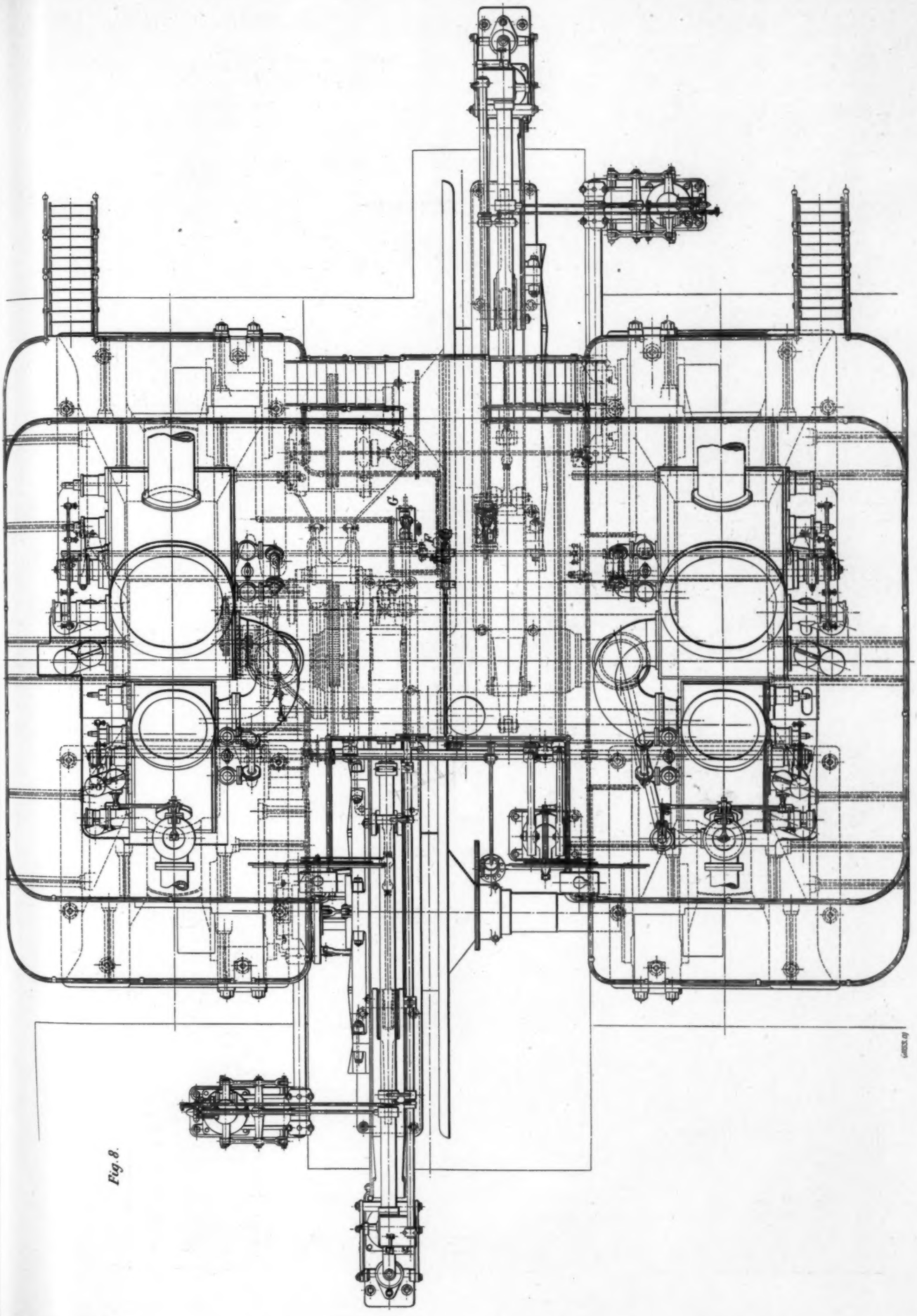

Fig. 8.

COMPOUND WINDING ENGINE FOR THE HOMESTAKE MINING CO.

CONSTRUCTED BY THE NORDBERG MANUFACTURING COMPANY, MILWAUKEE, WIS., U.S.A.

(*For Description, see Page 565.*)

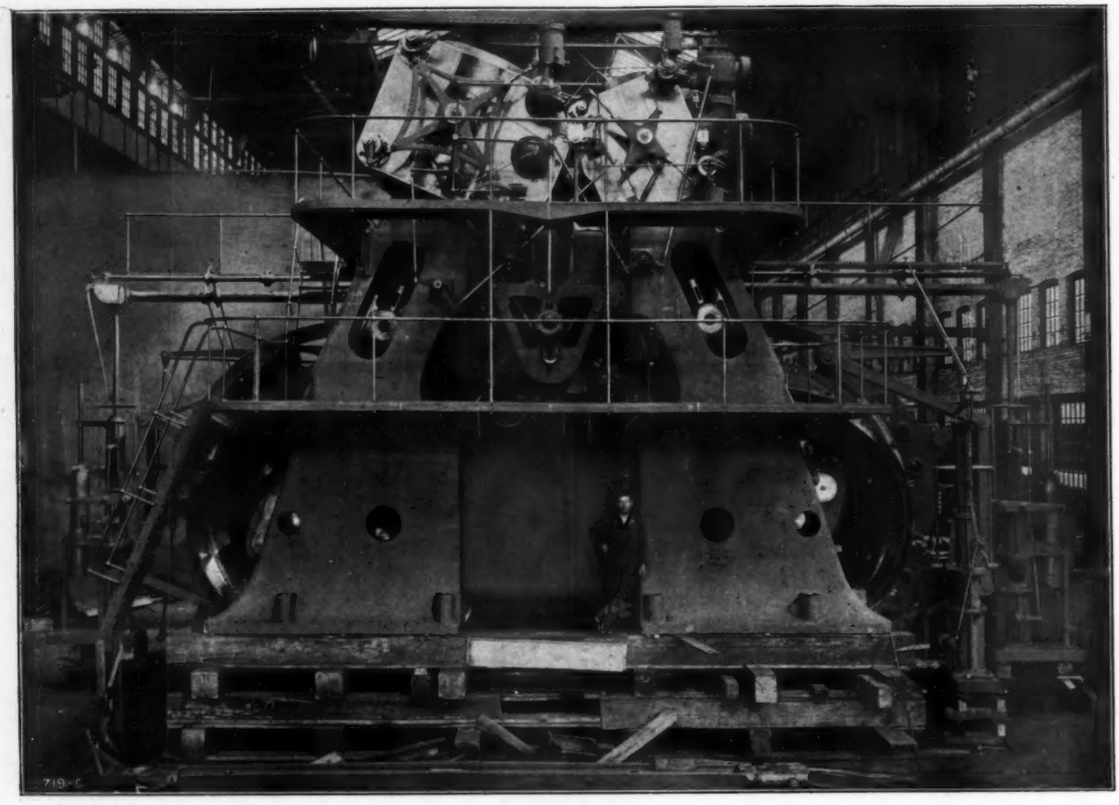

Fig. 9. Side View of Winding Engine.

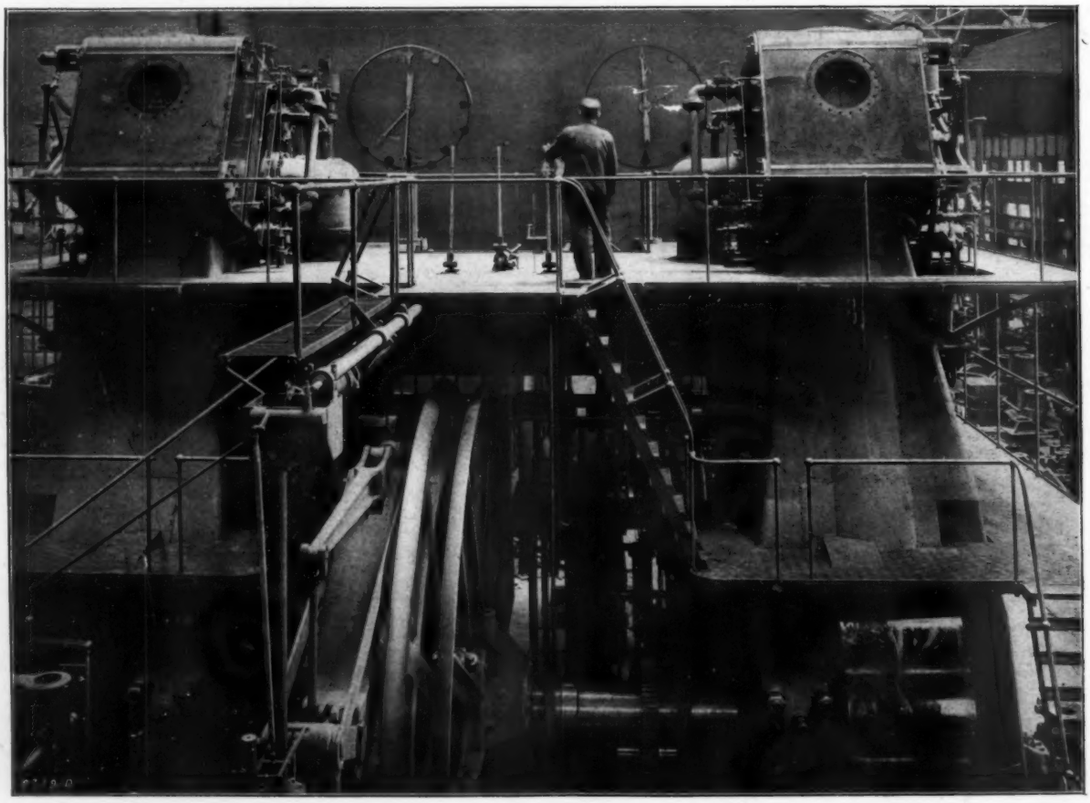

Fig. 10. View of Operating Platform.

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ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

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Thick paper copies	£3 7 6

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TELEPHONE NUMBERS—3663 and 8595 GERRARD

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With One Two-Page Plate and Two One-Page Plates of a COMPOUND WINDING ENGINE FOR THE HOMESTAKE MINING COMPANY.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 571.

ENGINEERING.

FRIDAY, OCTOBER 21, 1921.

STANDARDISATION IN THE MOTOR INDUSTRY.

ALTHOUGH we have mentioned it before, it is well worth repeating that in the twelve months ending October, 1920, the value of our automobile imports more than equalled the total value of our exports of agricultural machinery, electrical machinery, boilers, machine tools, prime movers, locomotives and textile machinery. The figures were given by Lord Weir in his presidential address to the Junior Institution of Engineers last December. We cannot say how matters will stand for the corresponding year closing at the end of the present month, but in view of the state of our export trade we hardly expect them to be any better. It will be admitted that for an engineering nation this record is not very satisfactory. In some way and for some reason this country is not taking the place it should in the group of industries which have been called into being by the invention of the petrol engine. The matter is a serious one, the group being unquestionably among the most important in the whole range of engineering manufacture.

Any discussion of this subject at the present time is of necessity coloured by the very serious condition of both home and foreign trade. This condition is in no way peculiar to the motor industries, but in some respects they have been unusually hardly hit. As is well known the majority of our motor car manufacturers were during the war engaged on other branches of work, and as a consequence the Armistice found them in no position to cater properly for the business which offered, while the very extensive arrangements which were subsequently made to take advantage of the post-war boom were little more than completed when the boom had become a slump. These conditions applied very generally to the motor car trade, and while the maker of commercial vehicles was not usually affected in quite the same way as the car builder, his market was seriously interfered with by the sales of ex-army lorries.

Before the war the motor trades in this country were in a reasonably prosperous condition, although it is doubtful if even then they were holding their own with American competition. No profit, however, lies in a discussion of the possible present position of the British motor industry on the assumption that there had been no war. Things must be considered as they are, and there is no doubt but that American manufacturers have now obtained a very valuable position both in foreign trade and in our home trade. In this connection it is interesting to note that a survey of the programmes and products of British firms during the last three years suggests that the car builders have in the main devoted their consideration and efforts to the development of home markets. This has probably been a reasonable proceeding, in view of the potentialities of that market. As Lord Ashfield pointed out at the dinner of the Institute of Transport last week, there is one motor car to every 11 inhabitants in the United States, while in this country the proportion is only 1 to 43. It is impossible to say if the motor car density in Great Britain will ever equal that of the United States, but in any case there would appear to be a very considerable potential market here.

Admitting this, however, it is clear that if the whole of the programmes we were treated to some two years ago had materialised, the total product could not all have been sold in this country, and it would probably be of value if one or two of our firms would concern themselves particularly with the Indian and Colonial markets. The British car is mostly designed under disabilities imposed by taxation rules, and we submit it is at least worth considering if a wide-gauge, high-road-clearance, Colonial model built without reference to home taxation, might not prove a profitable investment by a British manufacturer. Questions of this kind, however, as well as the question of the cultivation of the potential demand that may be supposed to exist in this country, all however in the long run lead back to the question of economical production. Economical production does not necessarily mean a cheap car, and very large trades are done in the United States with cars differing very materially from the Ford. They are not cheap in the ordinary meaning of the word, but they are very good value for the money they cost.

This question of economical production is really the beginning and end of the British motor car problem, and any information or considerations which will help towards lower manufacturing costs is to be welcomed very genuinely. For this reason we look upon the Presidential Address delivered by Mr. G. W. Watson before the Institution of Automobile Engineers on the 12th inst. as of greater value than many presidential addresses to which we have listened. Mr. Watson termed his address "Industrial Standardisation," which is a somewhat wide subject, but fortunately it was essentially concerned with standardisation in the motor industry. Standardisation is a subject which engineers in general will have heard something about, but judging from some of their proceedings one wonders if our motor car builders have missed it altogether in their somewhat chequered careers. It is but some few months ago that we had occasion to point out that on 61 motor vehicles examined in France during the war there were 65 different sections of steel employed for the springs, lying within a range of from 1½ in. to 4 in. wide, and yet the Engineering Standards Committee was formed in 1901.

Mr. Watson referred to the special difficulties engendered in connection with mechanical transport in war when there is a complete lack of standardisation between different makes of lorry. This is a very important matter, but is one for the military authorities rather than the ordinary manufacturer. His immediate interest in the matter is, and must be, that standardisation may enable him to build more cheaply. Than this nothing can now be of more interest to him and to the country at large. That a proper system of standardisation would cheapen production requires no demonstration. The matter is obvious. We are not prepared to say that the more standardisation the more benefit. It would, no doubt, be quite possible to go too far, but in the early stages certainly the more standardisation the more benefit. If steel for leaf springs alone is standard the manufacturer may possibly be required to roll only ten sections instead of sixty. He can thus roll it more cheaply, and it can be bought and sold more cheaply. It would reduce the price of British cars—not much certainly, but cheapness in repetition manufacture is partly obtained by concentrating on details. If brake shoes were then standardised one would have the cheapening of a further item, and the process could with profit be carried very far.

To do justice to the motor car trade it must be admitted that there have long been some manufacturers who have realised the importance of this question, and Mr. Watson relates that shortly after September, 1910, a Committee was called together to consider the matter. He continues, however, that "the personal element was so strong that only a very meagre degree of standardisation was agreed upon," and even this was not carried into effect by more than half-a-dozen makers. We are afraid this quotation explains the backwardness of standardisation in this trade. As the motor car industry first developed in this country it was largely in the hands of enthusiasts, who were not always engineers, and the value of individuality in car design became over accentuated. This point of view persists even to this day, and too many makers would appear to think that some extra virtue lies in the use of a distinctive detail for which a standard part would be an entirely satisfactory substitute. For a very limited trade and a very limited class of car there is something to be said for the peculiar detail, but if the motor trade is to take the place its importance deserves in the range of engineering manufacture, it must be realised that the best machine at the lowest price are qualifications far outweighing the

value of five-aided nuts or any other such distinctive feature.

Of late years something has, of course, been done by the British Engineering Standards Association on the standardisation of automobile details, and some eleven specifications are in being covering sparking plugs, wheel rims, ball-bearings, &c. The work is being carried on by seven sub-committees of the Automobile section of the Standards Association, and they may be expected to do much to help a valuable movement forward. The standardisation of a large number of details may not in itself be enough to bring British production costs down to those of the United States, but it will help in that desirable direction. As Mr. Watson pointed out, "needless differences may be found in every factory where specialised articles are made, as, for instance, pistons, piston-rings, spring-shackle pins, &c." If such details as these can be standardised so that they can be made in really large quantities by specialising firms, it will do much to reduce costs. A movement of this kind well started may or may not develop to such an extent that the "assembled" car becomes a common British product. With our relatively limited home market as compared with that of the United States it is possible that we could not effectively compete in the assembled car for many years, but in any case standardisation need not be pushed to the limit. It is indeed not likely to be, but certainly it may, with profit all round, be carried very far beyond the point at which it now stands.

THE INDUSTRIAL CRISIS.

A few months back the Sheffield steel works were brought to a standstill as a consequence of the pitmen's proneness to profiteer, but to-day, whilst their sidings are filled with coal-laden wagons, many works have whole departments idle, simply because orders are unobtainable at prices compatible with present labour costs. The industrial situation is indeed most serious. In his interesting address delivered last Wednesday to the Industrial League and Council for the Improvement of Relations between Employers and Employed, Mr. E. W. Petter declared that the emergency is as acute as that which led some of the trade unions during the war to suspend certain of the more pernicious of their restrictions on output, and he contends that a similar concession is equally imperative to-day. To some extent no doubt some of the restrictions at present in vogue originated in the belief that by increasing output some other man would be deprived of a job. In a certain sense this is perfectly true. For example, it is reported this week that a South African contract for work to cost half a million has gone to America, because although the American mechanic is paid at higher rates than the British, his output is more than proportionately greater, so that the total labour costs are actually lower than here. In this sense therefore the high output of the American workman is depriving other men of a job, and no doubt if our own trades unions would agree to promote increased output by their members, German and Continental workmen generally would lose jobs which, as matters stand, will eventually be captured by them.

It is very remarkable what very curious ideas many workmen possess as to the relative receipts of capital and labour. A few months back a writer in the organ of the Patternmakers' Society based an argument against payment by results on the hypothesis that, in normal conditions, profits were three times the wages cost. On this head some interesting statistics were published in Germany two or three years ago. In these it was shown, taking exceptionally prosperous manufacturing companies paying dividends far above the average, that the divisible profits per employee were some 12*l.* 10*s.* per annum (taking the mark at its pre-war rate). The average return in this country before the war was, for the engineering trades, of the order of 8*l.* to 9*l.* per employee per annum, and for this return the workman was provided not merely with material, tools, power, light and guidance, but a market was also found for his products, which in the ultimate outcome have to be exchanged for the products of men engaged in other pursuits, or for the services of doctors, journalists, postmen, cinema actors and the like. In short, as Mr. Petter insisted, the consumer is in all cases the real employer, and if the workmen produce goods at prices which as consumers they reject, they are, in fact, refusing to employ themselves.

Mr. Petter, whilst recognising that large individual incomes do excite the envy of the less intelligent of the commonalty, maintains that on the whole it is better that the capital of the country should in the main be in individual hands rather than in that of the State. This is certainly in accord with all past and present experience, and Mr. Petter pointed out one very important factor which is largely responsible for this. The individual capitalist is much more concerned in stopping waste than any public official. Waste impoverishes the community as a whole, and not merely the immediate sufferer. The present industrial crisis is the result of the stupendous waste of wealth during the war, aggravated no doubt by much additional waste since the Armistice, part of which was probably unavoidable, in view of the actual conditions. Much, however, was by no means inevitable, but the fault was less attributable to the errors of a much harassed and overworked Cabinet than to the obtuseness of organised Labour. We note from the presidential address of Mr. W. J. Noble that already this year 77,000,000 working days have been wasted through strikes. So serious has the situation become in the shipbuilding industry that our former preponderating position is now seriously threatened. During the war British tonnage decreased by 13½ per cent., but this figure greatly under-estimates the effective loss. Our heaviest losses were, in fact, on our largest and most up-to-date vessels, and thus, although our tonnage is 400,000 tons gross more than in 1914, it is not, he states, nearly as efficient for transportation purposes as it was before the war. Moreover, in 1914 we owned 44½ per cent. of the world's tonnage, and this position was secured by the extraordinary pluck with which our shipowners, shipbuilders and engineers took pioneering risks. Now our proportion of the aggregate tonnage is but 35½ per cent. of the gross total, and, as stated, the ships are relatively less efficient. With building and repairing costs at present figures it is difficult to see how the situation is to be retrieved, but as American experience has shown, there is no invariable relationship between rates of wages and labour costs, and it is the latter which must inevitably be reduced. With the willing co-operation of the men this reduction of labour costs may be effected with a relatively small diminution in rates of pay; but if this co-operation is not forthcoming very heavy cuts in wages will be unavoidable if work is to be found for our yards. After all, we have to support some 47,000,000 people on an area which, if self-contained, could not yield a living to one-half this number. Hitherto we have succeeded by exchanging our products for those of other countries, but this exchange cannot permanently be other than an equitable one. The producer of meat in the Argentine will not in the long run be content to give more of his product than formerly in exchange for the products he purchases from us.

In his address Mr. Petter stated that many people had said to him, "Starve, why I will steal before I starve." Irrespective of the consideration that the Poor Law effectually provides against the risk of actual starvation in this country, such observations show a remarkable lowering of the ethical standard of the community as compared with a couple of generations ago. It would at that time hardly have been possible to find outside of the limits of the "intelligenzia" (so called on the *lucus a non lucendo* principle), any one capable of such a remark as the foregoing. There are, we believe, certain tribes on the North-Western frontier of India whose lands are so barren that they maintain that they can only conserve their existence by periodical raids on the industrious husbandmen of the lower levels, but even here there is a limit to the amount that can be stolen without the husbandmen migrating elsewhere. No doubt the looting of provision shops, granaries and stores generally might relieve the immediate wants of Mr. Petter's interlocutors, but, as in Russia, the ultimate effect would merely be to make more certain than ever the ultimate starvation of the raiders. Our farmers would cease to produce more than they needed for their personal requirements, and there could be no replenishment of the stores derived from overseas.

RESEARCH AND PROGRESS IN SHIPBUILDING.

At first sight the present time of stagnation and depression may not seem the most opportune for urging expenditure on research in the shipbuilding industry, but more careful consideration will show that such expenditure may nevertheless be well advised. If it be admitted that progress in the past has been furthered by research of the right kind, it will probably be allowed that a similarly beneficial effect is to be anticipated in the future, and there can be no question that any stimulus which can help to restore the industry to a position of prosperity should be applied at the first possible opportunity. That research may provide such a stimulus, we gather, is the view of Mr. Harold E. Yarrow, C.B.E., who, in his presidential address to the Institution of Engineers and Shipbuilders in Scotland, delivered on Tuesday last, traced the effect of scientific research in connection with the development of high-speed craft of the torpedo-boat type during the last fifty years, and advocated its more extensive employment in the future.

He pointed out that the speed of such vessels had increased from about 15½ knots in 1872 to 40 knots at the present time, and ascribed this progress to the cumulative result of investigations by naval architects, marine engineers and metallurgists. The form of the hull, he pointed out, had, through tank experiments on models, been modified to secure the minimum resistance, and, as further evidence of the value of this work, he mentioned that the average fuel consumption over a wide range of ships had been reduced by 5 per cent. by model experiments at the National Physical Laboratory. Mr. Yarrow also referred to investigations carried out to ascertain the effect of shallow water on high-speed craft, explaining that it had, at first, been thought that the speed was reduced in shallow water. Experiments with a destroyer had shown, however, that the speed was unaffected in water over 180 ft. deep, was considerably reduced at a depth of about 90 ft., but increased again at depths ranging from 30 ft. to 50 ft. With regard to progress in constructional materials which had enabled much lighter and stronger scantlings to be employed than was formerly the case, Mr. Yarrow referred to the work of metallurgists which had led to the introduction of nickel steel and high-tensile steels. Bronze for propellers and special steels for machinery parts, he pointed out, had also resulted from metallurgical investigations. In the matter of marine propelling machinery of the reciprocating type for the class of vessel under consideration, Mr. Yarrow referred particularly to the work of Messrs. Normand, of Havre, and mentioned that the indicated horse-power per ton of machinery (including main and auxiliary engines and boilers with water) had increased from about 27 in 1886 to 65 in 1895.

Further development of the reciprocating engine was, of course, arrested by the introduction of the steam turbine by Sir Charles Parsons, which had enabled powers on one shaft to be increased from about 4,000 (the maximum practicable with a light reciprocating engine) to 15,000 or 20,000 in a modern destroyer. Reflection on the development of the steam turbine, Mr. Yarrow remarked, should serve to remove any existing doubts as to the value of research work. With boilers, the problem has been to obtain the maximum evaporative power in conjunction with the minimum weight, and Mr. Yarrow dealt with some of the investigations of this problem which have resulted in the employment of water-tube boilers fired with oil fuel and capable of producing 120,000 lb. of superheated steam per hour. It was obviously impossible to mention, in the course of a brief address, more than a few of the problems already solved, even in the one particular class of work considered. Enough was said, however, to show that research has been a valuable aid to the industry in the past and to support the view that its application to the many problems still requiring attention is well worthy of encouragement.

THE COMMERCIAL MOTOR EXHIBITION AT OLYMPIA.

Commercial motor vehicles, however the term is defined, have now become so familiar a part of our daily life that they no longer arouse the interest they did when first they commenced to supplant horse-drawn traffic. The public takes them for granted, and such emotions as they excite in the majority of individuals are concerned with the necessity of getting out of their way. Their importance, however, is not to be measured by the amount of public attention they receive. They have risen from the position of mere noisy novelties and taken their place in the established order of things which are as necessary to our civilisation as railway trains or steamships. Every year shows a vastly greater volume of mechanically-propelled traffic over our roads both in towns and in the open country, and in spite of the acute depression which the commercial vehicle manufacturing industry is suffering from at the present time, its future is as assured as that of any industry in the country. It has, indeed, a wider field for expansion than many others, and if, as seems possible, our manufacturers are going to take the lead in producing ordinary road vehicles to run on steam or producer gas, with a consequent enormous reduction in fuel costs, the British motor vehicle industry has very good times ahead of it.

The modern ramifications of the commercial motor vehicle are well exemplified in the fifth International Commercial Motor Exhibition, organised by the Society of Motor Manufacturers and Traders, which was opened at Olympia on Friday last. No type of vehicle for road transport or service seems to be unrepresented. Motor coaches, omnibuses, lorries, delivery vans, tipping wagons, road sweepers, tank wagons and fire engines are all to be seen, and in many cases chassis, engines and detail parts are presented for inspection separately. The main hall and the annexe are well filled with the heavier exhibits, while the gallery is mostly devoted to the innumerable "accessories" which play so large a part in the motor trades. Regarding the show as a whole it is a good and varied display, but not particularly noticeable for engineering novelty. The growth of the motor coach has produced new designs in body-work, some of which is remarkably well carried out, but engines and chassis remain very much as they were last year. Design seems to have settled down along standard lines, at any rate so far as all the leading makers are concerned. Details, of course, differ, and frequently the difference appears material, but the fact that each maker appears satisfied with his own particular solution of his mechanical problems, and produces vehicles which behave much the same in service as those of his competitors do, tends to disarm criticism of features which otherwise one might consider faulty. It may be taken for granted that every maker is perfectly conversant with the designs of his competitors—indeed, if he visits shows such as the present one he could hardly fail to be. Such interchange of knowledge is an excellent thing for the general advancement of the industry as it tends to the rapid elimination of inefficient or unnecessarily costly design, and so widens the circle of satisfied purchasers. It carries with it, however, the corollary that such variation in detailed design as persists between different makers can hardly be of great importance in practice. This emphasises the plea for standardisation made by Mr. G. W. Watson, M.I.Mech.E., in his recent presidential address before the Institution of Automobile Engineers, especially as standardisation of details would permit of their manufacture in quantities by firms specially equipped for the purpose, besides rendering similar fittings interchangeable among the different types of vehicles.

As on previous occasions we have given full illustrated descriptions of many of the leading vehicles, we do not propose to go again over the same ground, but rather to confine ourselves to the general impressions created by the Show as a whole. Prices all round appear to have been very substantially reduced, and there is an eagerness on the part of exhibitors to encourage business which we hope will receive its reward. As regards the exhibits, the great majority of the vehicles have the ordinary petrol engine and transmission gear on the lines of a motor car. Messrs. Tilling-Stevens Motors, Limited, of Maidstone, Kent, who for many years have been the chief exponents of the petrol-electric system, show charabancs, double-deck omnibuses and chassis of this type. The fact that the second largest omnibus company in the country has a fleet of over 300 vehicles, all operating on the petrol-electric system, shows that the principle is one to be taken seriously, and figures as to the relative costs of maintenance of electric transmission as compared with gearing and clutches would be very interesting. The initial cost of a petrol-electric chassis, judging from the catalogue prices, appears to be slightly less than that of a corresponding chassis with mechanical transmission, at any rate for the larger sizes.

Steam-driven vehicles are represented by most of the types which are so familiar on the roads, and steam power seems to have no difficulty in holding its own so far as road tractors and the heavier wagons are concerned. For anything up to 3 tons or 4 tons capacity, the petrol-driven vehicle at present holds the field, but whether it can continue to do so, in view of the enormous discrepancy between the price of solid fuel and of petrol, is a matter which is by no means certain. Two rivals to the petrol lorry have already got beyond the stage of experimentation, and judging by the amount of interest they are exciting at the Show, there can be no doubt of the anxiety of those concerned in road transport to free themselves from the monopoly of petrol. The use of producer gas for road vehicles has been advocated for several years by Colonel D. J. Smith, and we understand that there are some 60 vehicles on the Smith system now on the roads, and that they are successfully operating between London and Manchester. No complete producer-gas vehicle is shown at Olympia, but a producer plant, made under Colonel Smith's patents and known as the "Sphere Producer," is exhibited by Messrs. G. D. S., Limited, of Oakfield-road, Altrincham, Cheshire. As the plant can be fitted to any ordinary type of commercial vehicle, the omission to show such a vehicle is of no importance, particularly as, on the stand, a cab has been fitted up to show the arrangement of the producer alongside the driver. The internal diameter of the producer is only 9 in., and mechanically-operated reciprocating firebars keep the fire in good condition. The details of the plant will be generally known to engineers, as they were described in a paper read by the inventor before the Institution of Automobile Engineers, and published in full in our issues of January 9 and 16, 1920. It will be remembered that an ordinary petrol lorry, weighing 3 tons 15 cwt. unloaded, and carrying a useful load of 29 cwt., was shown to cost 3*l.* 10*s.* 10*d.* for a run of 100 miles, with petrol at 3*s.* 4*d.* per gallon. The same vehicle was fitted with a producer, no overhauling or other alterations being made prior to the test. The fuel cost was only 4*s.* 8½*d.* for the same run when anthracite, at 40*s.* per ton, was the fuel used. Both figures would have been reduced had the engine been in proper order, but they are sufficient to show the enormous saving possible. Indeed, to compete with the producer petrol would have to be purchasable at about 2·6*d.* per gallon.

Although such fuel economies are not possible with steam plant, the latter has nevertheless a tremendous advantage over the petrol engine in the matter of fuel costs, and the fact that a small and simple boiler and steam engine is likely to appeal more to many engineers than a gas producer and internal-combustion engine will no doubt largely offset the superior efficiency of the latter. Other things besides fuel cost have to be considered in road transport, and the flexibility of the steam engine, coupled with the fact that it will continue to operate under almost any condition short of actual breakage, are factors which to many people would outweigh the greater fuel economy of the internal-combustion engine. The protagonist of the steam-driven lorry is Mr. Thomas Clarkson, and two chassis of his design are to be seen at Olympia on the stand of Messrs. Clarkson Steam Motors, of Chelmsford. The stand also contains separate details, such as the boiler, &c., so that the construction of every part may be fully examined. The engine is of the two-cylinder compound vee type with piston valves, and as reversing is effected by means of a gear-box, as is done with petrol lorries, the engine is of extremely simple construction. We illustrated and described it fully in our issue of August 19 last, so that there is now no need to repeat the description. One alteration, however, is to be noted, namely, the elimination of the vertical chimney by causing the products of combustion to travel downwards after leaving the boiler. This is effected by altering the position of the steam jets which cause the draught. Our previous article referred more particularly to the engine, boiler, and their attachments, but as the axle and gear-box are also of interest we intend to illustrate them separately in our next issue. A 3-ton Clarkson lorry, when working 80 miles to 100 miles per day, will only consume 4·5 lb. of coke per mile, and if the price of coke be taken as 40*s.* per ton, the fuel cost per mile works out at less than 1*d.*, or about one-fifth of that of a petrol vehicle.

Electric vehicles give the impression that they are growing in favour, and several are to be seen at Olympia. Messrs. Clayton Wagons, Limited, of Lincoln, and Guy Motors, Limited, of Fallings Park, Wolverhampton, show electric vehicles for the first time, the former exhibiting a 3-ton wagon with tipping body and the latter a 2½-ton chassis. Other exhibitors of vehicles of this type are Messrs. Richard Garrett and Sons, Limited, Leiston; Newton Brothers, Limited, Derby; The General Vehicle Company, Limited, 43, Shoe-lane, E.C. 4; and Messrs. Ransomes, Sims and Jeffries, Limited, of Ipswich. The centre of attraction on the stand of the latter firm is, however, a 15-cwt. electric runabout crane for general use, which we illustrate and describe on page 564 of the present issue, so that details need not be mentioned here.

THE INSTITUTION OF RUBBER INDUSTRY.

Whilst we would hardly encourage the foundation of new technical institutions on general lines, we do not withhold a welcome from the Institution of Rubber Industry which was inaugurated on Wednesday evening last in the rooms of the Royal Society of Arts. Among the industries rubber certainly occupies a special position, as rubber does chemically and physically, for no science nor industry can at present dispense with rubber. One may rather wonder, therefore, that rubber has not sooner had a technical home of its own, but this is so, probably because the rubber interests are so widely ramified.

Two years ago, as we learn from the address delivered by the president of the new Institution, Mr. J. H. C. Brooking, M.I.E.E., an agitation in favour of some rubber association was set in motion by Mr. Fordyce Jones. When, however, as a consequence the Rubber Club of Great Britain had been initiated, it was recognised that the name was a misnomer, and the title "Institution of Rubber Industry" certainly indicates much better that a body has been established which is to promote the interests of the rubber growers, manufacturers and distributors and to advance the general standard of the rubber industry. It is not quite accidental, of course, that the rubber industry is a hundred years old at the time of the foundation of the Institute. In 1820, Thomas Hancock began to manufacture rubber; in 1843 he took out his patent on vulcanisation—first by dipping rubber into molten sulphur—and he vulcanised almost everything.

Within a few years inflated rubber tyres, spongy rubber, engine valves, rubber-cork preparations, &c., were on the market, and Hancock's catalogue of 1857, pages of which Mr. Herbert Rogers, general manager of Messrs. J. Lyne, Hancock and Co., afterwards threw on the screen in his discourse on the development of the industry, showed all the variety of gloves, boots, pillows and other "quite modern" rubber ware of an advertisement of our days. And there is little new in rubber as in everything else. The smoked rubber, such as the Indians made in the days of Columbus, is still unsurpassed in quality, and Hancock was

partly anticipated, as was the water-proofing rubber solution of C. Macintosh, also of 1843. But both these men were the fathers of the industry all the same, and some of Hancock's machines remain remarkable.

By the year 1873, the world's production of rubber was estimated at 15,000 tons; in 1919, it reached nearly 400,000 tons, and a large portion of that rubber is now grown in plantations which we owe to Sir Henry Wickham's exploit of 1876. Sir Henry was present last Wednesday, and Mr. Brooking told how the first seeds of hevea were shipped, at considerable risks and without the knowledge of the Brazilian Government, as "delicate botanical specimens," down the Amazon over to Liverpool, and how Sir Joseph Hooker raised 7,000 rubber plants in Kew Gardens, which were then transferred to Ceylon. Mr. Brooking had something to say also on the shady side of the industry, on the injury done to it by inferior imitations of good ware and by price cutting. It was further acknowledged that the secrecy of the manufacturers had retarded developments. That members and visitors were interested was shown by the fact that the meeting, opened at 7 p.m., lasted quite 2½ hours. A series of instructive papers are announced. The Institution, which owes much to its first president, will hold its next two meetings in Manchester on November 7, and in London on November 15; Mr. W. Tyson, of Charing Cross House, Charing Cross-road, W.C. 2, is the secretary. We wish the new Institution every success.

NOTES.

Development in Roads.

The subject of development, chosen by Sir H. P. Maybury, K.C.M.G., for his presidential address before the Institute of Transport, is so wide that it must have proved rather difficult to set a limit to its manner of treatment. Sir Henry, however, confined himself practically to the special field within which he has laboured recently, and dealt with roads and the provision for urban and inter-urban road traffic. Its an ill wind that blows nobody any good, and Sir Henry points out that though public works may be objected to as unsatisfactory palliatives in unemployment crises, in this particular year their encouragement will have resulted in the very practical improvement of many of our roads, and the construction of several badly wanted relief channels. The early action of the Government, last autumn, in devising a scheme of assisting road schemes has led to works estimated at over 10,000,000*l.* being put in hand. The terms of the Government were welcomed, and the unemployment crisis, coupled with the financial aid, enabled many of the difficulties arising from multiplicity of authorities, to be brushed aside so that many important changes will result in the road maps of the country. In the neighbourhood of London the work is steadily progressing. Among the more important in hand of these road schemes, are the Eltham by-pass, Shooters' Hill by-pass, South Circular road, North Circular road, Western avenue, Eastern avenue, East Ham by-pass, and New Cambridge road. Similar progressive action is being taken in many of the large provincial towns and cities. Referring to the census, Sir Henry quoted the fact that 79 per cent. of our population now resides in urban areas compared with 72 per cent. thirty years ago; the interesting fact was also stated that while the London County Council area had decreased 1 per cent. in population, the Outer Ring of London had increased 9·6 per cent., showing that we are becoming more and more a suburban people, and as such require far greater facilities in the way of transport arrangements if only our business is in the central area, and not our residences. Dealing with aspects of the development of London, Sir Henry Maybury referred to the recent opening of the new King George V. Dock, and mentioned that the deficient access to the dock area was a great blot on the London traffic map. In this connection he thought that the idea of an additional Thames Tunnel connecting Kent and Essex was not at all an impossible scheme, while the whole of the triangle between Chelmsford, London and the Thames required development in view of the fact that great changes might be anticipated along the river, and at seaside resorts such as Southend, which in the ten lean years through which we had passed, had expanded 50 per cent.

Losses of Merchant Vessels.

For the first time since the termination of the war full statistics of the losses suffered by the merchant navies of the world owing to ordinary marine risks have now been issued by Lloyd's Register. From these it appears that, during 1920, a total of 561 vessels, making collectively 645,603 tons, were lost from what may be described as natural causes, in order to distinguish them from the losses due to enemy action during the course of the war. The above-mentioned figures include 357 steamers of 510,794 gross tons in the aggregate, and 204 sailing vessels, making 134,809 net tons together, and they refer only to vessels of 100 tons gross or over in the case of steamers and net in the case of sailing vessels. Confining our attention for the moment, to steam vessels, we find, as might be expected, that in this class of shipping the United Kingdom is the chief sufferer, the British mercantile marine having lost 86 steamers with a total gross tonnage of 123,861. The latter figure is, however, only 0·68 per cent. of the total steam tonnage owned in this country, and the proportion lost compares quite favourably with that of most other maritime countries. The tonnage lost by the United States is proportionately higher than that of the United Kingdom, being 112,040 tons, which is 0·90 per cent. of the United States steam tonnage. French losses total 50,874 tons, and the percentage, in the case of that country, amounts to 1·72, while the corresponding figures for Japan are 41,988 tons and 1·40 per cent. Other interesting figures, in order of magnitude, are those for Norway (25,944 tons and 1·31 per cent.), Sweden (17,777 tons and 1·78 per cent.), British Dominions (16,574 tons and 0·89 per cent.), Russia (15,377 tons and 3·02 per cent.), Italy (13,020 tons and 0·61 per cent.), and Spain (10,050 tons and 1·07 per cent.); no other country has suffered losses exceeding 10,000 tons. The losses of sailing vessels, in proportion, are much higher, those of Norway, which amount to 26,704 net tons, representing no less than 11·13 per cent. of the total sailing tonnage owned in that country. The United States is, however, the largest owner of sailing ships, and the losses of that country amount to 47,654 tons. This figure is, however, only 3·44 per cent. of the total American sailing tonnage and, proportionally, is roughly equivalent to the losses of this class of shipping sustained by the United Kingdom, the figures for this country being 7,620 tons and 3·47 per cent. The only other figures worth mentioning are those for France and the British Dominions, the former having lost 12,992 tons of sailing vessels and the latter 12,448 tons between them. The losses of the British Dominions, it may be noted, are both actually and proportionally higher than those for the Mother Country, the proportion working out to 5·66 per cent. Some interesting figures of the war losses of shipping have also been given by Lloyd's Register, and from these it appears that a total of 4,877 steamers and 984 sailing vessels were lost by the maritime nations of the world by causes arising out of the war. The total steam tonnage lost was 12,562,187 gross tons, and the sailing vessels account for another 671,485 net tons. The losses were most serious in 1917 when the German submarine campaign was at its height, no less than 2,211 steamers, making 5,957,913 gross tons, being lost in that year, in addition to 523 sailing ships totalling 392,449 net tons.

The Reduction in the Cost of Production.

On Wednesday last a conference of the British Engineers Association was held in London to consider the problem of restoring vitality to the industry. Speaking at a luncheon between the morning and afternoon sessions, Lord Weir asked what could be thought of statesmanship which provided relief schemes for unemployment and discussed credit plans, but left unconsidered the fact that we were importing more foreign material than ever instead of manufacturing here. During the last nine months we had imported 19,000,000*l.* worth of iron and steel, and in the month of September these imports were higher than ever before. There was a definite amount of foreign trade, but for some reason we were not getting hold of it. The factors affecting the situation were numerous, but he wished especially to emphasise two. One was that some countries abroad, able to buy a certain amount, were not buying from us; the other was that our prices were regarded as artificially high, and in the expectation of a fall, possible customers were holding their hands. There was, further, a lot of home trade going, and we were not getting that. In the meantime the Government could only suggest relief works, so that they had the extraordinary situation of relief works instituted, say, in Lanarkshire, with their steel works and mines shut down, while the port of Glasgow was full of ships bringing in imported steel to be made into bridges, &c. Was it better to grant credits in connection with the export of goods made from imported material, or to withhold such credit until the makers and men could come to some agreement as to how to make steel in this country? There was no doubt that our trade was governed by cost of production and it was this that required investigation. Considered apart from wages, our costs were inflated by unjust conditions. Against all the restrictions and regulations conceded to trades unions, he could not find a solitary action of those bodies which had tended to decrease costs. Their policy had always been based upon the assumption that their demands could be met out of the profits of the employer, or that the cost could be passed on to the customer. This had now been proved false. Very few realised the cost enhancing effect of shorter hours. Coming on the top of the dislocation of the war it was difficult to see how they were warranted, combining as they did an additional 200,000,000*l.* in wages cost with decreased output. The idea that shorter hours resulted in improved output had unfortunately been disproved. There were rules and restrictions which taken together represented heavy additions to costs, and which could be abolished without any reduction in the earnings of the men. Further wage reductions should only be contemplated when these matters had been discussed. The unions looked to the Government to revive trade; that was impossible, as the matter rested between the employees and employers, and the best service the Government could do was to tell the trades unions the truth. The Conference discussions ranged over many subjects. It recorded its opinion on, among other points, the need for national economy, the loyal co-operation of labour, of amending the conditions now governing the output per 1*l.* of wages, of a secret Trades Union ballot, of the repudiation by the Trades Unions of the extremist policy antagonistic to capital and private enterprise, the development of markets within the Empire, cheaper coal, and so on.

THE CERAMIC SOCIETY.

(*Concluded from page 537.*)

We now conclude our report of the meeting of the Ceramic Society, held in London, on October 6 and 7, the account of the earlier proceedings having appeared in our issue of last week.

The Reversible Thermal Expansion of Silica.

Perhaps the most important paper presented at the meeting was that on "The Reversible Thermal Expansion of Silica," by Mr. H. S. Houldsworth and Professor J. W. Cobb, which was read by the former. The reversible thermal expansion from 15 deg. to 1,000 deg. C. was measured for amorphous precipitated silica prepared from silicate of soda and containing some alkali, pure amorphous silica prepared from silicon fluoride, silica glass, ganister (both with and without a lime bond), quartzite and flint, after preliminary firings to known temperatures. Generally the test pieces were fired in a works kiln to cone 06 (980 deg. C.) in 48 hours, or to cone 9 (nominally 1,280 deg. C., but pyrometers showed 1,170 deg. C.) in 72 hours, before examination. Afterwards the specimens fired to the latter temperature were fired for 2 hours in a laboratory furnace at cone 14 (1,410 deg. C.) and their expansions again determined. They were then fired at cone 20 (1,530 deg. C.) for 2 hours and again examined. Wherever possible, the substances were also examined without any preliminary firing. The tests also included unused commercial silica bricks and silica bricks which had been used in coke ovens or steel furnaces. The porosities and true specific gravities of the materials were also determined. Refractive indices were tested by immersion of the finely-powdered substances in oils of known refractive indices.

Precipitated silica containing 5 per cent. of soda, after heating to 700 deg. C., expanded only slightly between 15 deg. C. and 170 deg. C., but from this to 210 deg. C. a large, rapid and reversible expansion was noted (presumably inversion of α to β cristobalite). From 210 deg. to 420 deg. C. the specimen expanded steadily, and thence on to 700 deg. C. it contracted. The results suggested conversion into cristobalite but not quartz. After heating for 2 hours at 700 deg. C. and then reheating, the rapid expansion between 170 deg. and 210 deg. C. was found to be about three times that previously noted. The easy conversion of precipitated silica into cristobalite was unexpected, as Fenner had not obtained cristobalite from precipitated silica. Another test-piece was heated in a muffle to 790 deg. for 2 hours and examined, when it showed an increased rate of expansion about 115 deg. to 120 deg. C., and a much larger coefficient of expansion about 200 deg. C., with a little further expansion above 300 deg. C., whilst from about 470 deg. C. up to 700 deg. C. a contraction took place. It would seem that the amorphous silica had been thus converted into tridymite (only a little) and cristobalite. After keeping the test-piece at 650 deg. to 710 deg. C. for 70 hours there was less tridymite than before, but again no quartz. After further heating for 91½ hours at 680 deg. to 720 deg. C., there was evidence of still more cristobalite, but no quartz. After 768 hours heating, the expansion about 200 deg. C. had gradually diminished to a minimum. This long heating had produced cristobalite, and not the quartz which would have been expected at this temperature according to the stability ranges given by Fenner, and even tridymite could not be detected except a few grains by the refractive index, but there was a little unchanged amorphous silica.

Precipitated silica heated to 1,150 deg.—1,170 deg. showed steady expansion to 100 deg. C., with five times that expansion (reversible) between 100 deg. and 200 deg. C. From 200 deg. to 550 deg. C. the coefficient of expansion was nearly the same as from 15 deg. to 100 deg. C. From about 550 deg. to 1,000 deg. C. a slight contraction was observed. Tridymite was present in quantity. This formation of tridymite gave support to Fenner's view that tridymite is the most stable form of silica at the temperature.

Precipitated silica fired five times at cone 9 in a works kiln showed a large expansion between 100 deg. and 170 deg. C., then a fairly large but regular expansion to 550 deg. C., followed by a contraction from 550 deg. to 1,000 deg. C. No quartz was detected, nor unconverted amorphous silica. At least half the specimen was tridymite, the rest being cristobalite. The specific gravity was 2·28. When precipitated silica was fired at cone 14–15 for 2 hours it gave results very similar to the preceding, there being no quartz or unchanged amorphous silica, but roughly equal amounts of tridymite and cristobalite.

Pure amorphous silica (prepared from silicon fluoride), after heating at 700 deg. C. for many hours, showed no conversion into any crystalline form of silica. Pure amorphous silica heated to 1,150 deg.—1,170 deg. C. showed formation of cristobalite, but not of tridymite or quartz. The refractive index test showed the presence of a little tridymite. Pure amorphous silica heated to cone 14–15 showed the bulk of the material again converted into cristobalite. Silica glass (vitreosil) was not appreciably changed by repeated heatings to 1,000 deg. C. The same result followed after heating to 1,150 deg.—1,170 deg. C. for 4 hours. Vitreosil after heating to cone 14–15 for 3 hours showed no measurable change in its thermal expansion, but the refractive indices of the powdered material indicated unaltered glass with some tridymite and a few crystals of cristobalite. Vitreosil after heating to 1,510 deg.—1,555 deg. C. for 2½ hours showed according to refractive indices a mixture of tridymite and unchanged vitreosil, but no quartz or cristobalite. Further investigations are contemplated.

Meanwood ganister without bond, on heating for the first time, had a very large expansion from 15 deg. to 500 deg. C., and did not exhibit any marked discontinuity in this range. From 500 deg. to 600 deg. C. the rate of expansion was still greater, from this to 900 deg. C., the coefficient of expansion of the ganister was small, and there was a slight contraction from 900 deg. to 1,000 deg. C. On cooling, the reverse changes took place excepting a permanent linear expansion of 0·7 per cent. On reheating, the temperature-expansion graph was of the same character from 15 deg. to 600 deg. C. as that obtained on the first heating, but the actual expansion was only about two-thirds as much. From 600 deg. to 1,000 deg. C. slight but steady contraction took place. The cooling curve did not differ appreciably from the heating curve, but from 400 deg. to 15 deg. C. the contraction was less than the corresponding expansion, so that a further permanent linear expansion was shown, but there was no indication of appreciable amounts of tridymite or cristobalite. The true specific gravity of the raw ganister was 2·65, and after three heatings to 1,000 deg. C. only changed to 2·64, so that very little or no transformation of the quartz had taken place, though the porosity had changed from 14·4 per cent. to 17 per cent., and this difference more than accounts for the increase in length. A very slight permanent expansion (0·01 per cent. of the original length) was noted after the third heating. The increase in dimensions of the ganister on heating to 1,000 deg. C. was thus due to increase of porosity resulting presumably from a re-arrangement of the quartz particles, and is important to makers and users of all bricks made from quartzitic material.

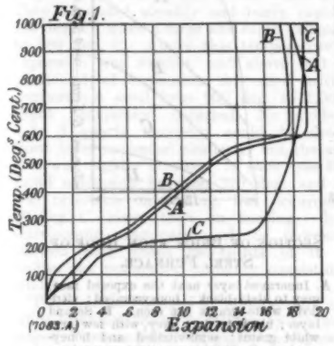
Meanwood ganister fired repeatedly at cone 9 (in a works kiln) until no further expansion was noticeable, showed an average increase in length of 1·92 per cent. As the specific gravity was 2·59, less than half of this permanent expansion was due to conversion of the quartz into cristobalite or tridymite, and the other part of the permanent expansion must be attributed to an increase of porosity. The temperature-expansion graph (Curve A, Fig. 1), showed that the substance was mainly quartz, with a small percentage of cristobalite. This inference was confirmed by the specific gravity 2·59, and also by microscopic examination for refractive indices.

Meanwood ganister fired at cone 14 for 2 hours (Curve B, Fig. 1), showed the conversion of a further small amount of quartz into cristobalite. This was confirmed by a slight reduction in the specific gravity, and also by microscopic examination. There was again no indication of tridymite. The same test piece was heated to 1,530 deg.—1,555 deg. C. for 2 hours, when practically complete conversion of the quartz into cristobalite took place, with some tridymite, the specific gravity being 2·325 (Curve C, Fig. 1).

Meanwood ganister with lime bond (Fig. 2) had on the first heating and cooling a permanent expansion of about 0·6 per cent., and a permanent expansion of 0·03 per cent. occurred after the second and third heatings. The porosity had increased by about 4½ per cent. as a result of the heating, and would account for the permanent change in dimensions without any conversion of the quartz. A sample after firing at cone 06 gave no indication of tridymite or cristobalite, which was confirmed by the specific gravity (2·63), and also by the microscopic examination. A test-piece after firing at cone 9 (in 72 hours) gave no indication of tridymite or cristobalite. The specific gravity, 2·60, confirmed the almost complete absence of tridymite and cristobalite, and microscopic examination showed quartz associated with a very small amount of cristobalite. The same test-piece after firing at cone 14 for two hours (Curve D, Fig. 2) showed conversion of part of the quartz into cristobalite, which was confirmed by the specific gravity, 2·49, and by microscopic examination. The same sample after firing at cone 19 for two hours (Curve E) showed a rapid conversion of quartz to cristobalite and tridymite, though the ganister without the plaster bond when heated from cone 14 to cone 19 showed rapid conversion of quartz to cristobalite but not tridymite. The test-pieces of ganister with plaster bond, fired to cones 14 and 19, gave little indication of the α to β tridymite or cristobalite inversions on the first heating, though they were clearly seen on cooling and on subsequent heatings. This phenomenon is important and has been observed repeatedly. It is suggested that owing to the rapid cooling in the laboratory furnace in which the specimens were fired, the crystals of α cristobalite or α tridymite did not form, and that during the first slow heating the α to β cristobalite or tridymite inversion would not occur, but that it would always occur afterwards. Or possibly the quartz in the process of conversion to cristobalite or tridymite first passes into an amorphous form which only yields crystalline cristobalite or tridymite on such prolonged thermal treatment as that of a slow heating. The difference in behaviour between ganister with and without added bond, after firing to 1,500 deg. to 1,550 deg. C., suggests that the bonding material was responsible for the delay in the expansion effect and therefore in the formation of the cristobalite crystals.

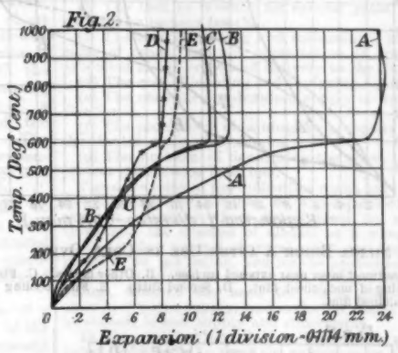
The transformations from α to β quartz are apparently not strictly reversible changes in mechanical structure. But since very little permanent change was noted in the dimensions of the specimens after heating, the particles presumably regained very nearly their original positions on cooling to air temperature.

Quartzite from Bwlchgwyn was tested for comparison with the ganister. The expansion-temperature curve, Fig. 3, obtained for the unfired test-piece was very like that given by the unfired ganister bonded similarly with plaster. The cooling curve was nearly the same as the heating curve, and the expansion observed on reheating was only slightly less than the expansion on the first heating. The permanent expansion after the first heating was only 0·09 per cent. compared with 0·6 per cent. in the case of the ganister. A further permanent expansion of 0·03 per cent. occurred after the second heating, and rather less on the third heating. The reversible thermal expansion of this quartzite from 15 deg. to 1,000 deg. C. was greater than that given by Meanwood ganister. The expansion after firing to cone 06 was almost identical with that for the second heating of the unfired specimen, there being no indication of tridymite or cristobalite. The specific gravity was 2·63, compared with 2·64 for unfired quartzite, and the index of refraction showed that it was unconverted quartz. Quartzite fired to cone 9 showed steady expansion to 150 deg. C., and thence on to 250 deg. C. a much greater rate of expansion. Then followed a smaller rate of expansion to 550 deg. C., when a large increase in the rate was observed to 600 deg. C., after which to 1,000 deg. C. there was practically no increase in dimensions. The cooling curve nearly coincided with the heating curve. The actual expansion to 1,000 deg. C. was the same as for the test-piece fired to cone 06. Thus, unlike the ganister, firing quartzite once to cone 9 converted some of the quartz into cristobalite, and did not appreciably



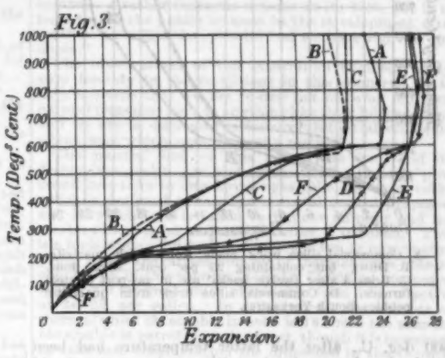
MEANWOOD GANISTER WITHOUT BOND.

A. After 6 burns at cone 9. B. After further heating for 2 hours at cone 14. C. After further heating for 2 hours at 1,530—1,555 deg. C.



MEANWOOD GANISTER WITH LIME BOND.

A. Unfired. B. Burned at cone 06. C. Burned at cone 9. D. Heated for 2 hours at cone 14. E. Heated for 2 hours at cone 19.



WELSH QUARTZITE WITH BOND.

A. Unfired. B. Burned at cone 06. C. Burned at Cone 9. D. Heated for 2 hours at cone 14. E. Heated for 2 hours at 1,510—1,550 deg. C. F. Quartzite flour burned at Cone 9.

decrease the expansion between 15 deg. and 1,000 deg. C. The specific gravity was 2·58, and the index of refraction also indicated quartz mixed with a little cristobalite. The same specimen fired for two hours at cone 14 showed a permanent expansion of 2·6 per cent. The heating curve and cooling curve were almost identical, indicating quartz with a large amount of cristobalite, which was confirmed by the specific gravity (2·35) and by microscopic examination. The test-piece was next fired at cone 20 for two hours, and the expansion-temperature curve indicated complete conversion of the quartz into cristobalite, a result confirmed by the specific gravity (2·33) and by microscopic examination. This conversion resulted in a larger expansion from 15 deg. to 1,000 deg. C. after firing at cone 14 or cone 20 than after firing to cone 06 or cone 9. But the bulk of this expansion comes within the range 15 deg. to 300 deg. C., leaving only a small increase between 300 deg. and 1,000 deg. C., an important point in furnace practice. Bricks in which quartz has been converted into cristobalite would experience no strain and danger of fracture from temperature fluctuations between 1,000 deg. and 300 deg. C., after the latter temperature had been attained, whereas bricks with much quartz would experience strain whenever the temperature fell below 600 deg. C.

Uncalcined flint showed a rapid rate of expansion from 500 deg. up to 700 deg. C., then a much smaller rate of expansion up to 850 deg. C., followed by a slight contraction. The specimen on cooling showed little change of length from 1,000 to 650 deg. C., but rapid contraction then took place down to 450 deg. C., after which there was a smaller contraction rate to 15 deg. C. There was a permanent expansion of 0·36 per cent. The second heating curve was very similar to the one obtained for flint previously calcined at about 1,000 deg. C..

Flint calcined at about 1,000 deg. C. previously to grinding gave an expansion-temperature graph almost identical with those obtained for unfired ganister and quartzite. After heating overnight at 1,000 deg. C. a permanent contraction of 0·33 per cent. was noted. In flint fired at cone 06 in a works kiln the heating and cooling curves were similar to those given by the material after heating in the expansion apparatus to 1,000 deg. C. The density, 2·56, agreed with that for the calcined flint before firing at cone 06. The refractive index showed that the whole of the material was unaltered quartz. Flint fired at cone 9 showed a large expansion from 15 deg. to 200 deg. C., followed by an extremely large increase in length between 200 deg. and 230 deg. C. The rate of expansion from 230 deg. to 550 deg. C. was less than from 15 deg. to 200 deg. C., but there was a further increase from 550 deg. to 600 deg. C., a small increase from 600 deg. to 900 deg. C., and a slight contraction from 900 deg. to 1,000 deg. C. The cooling curve was similar to the heating curve. The flint finally consisted of quartz and cristobalite, the latter being in excess. The specific gravity, 2·39, agreed with this, as also did the refractive index test, which indicated no tridymite. Flint fired at cone 13–14 for two hours (after previous firing to cone 9) showed a large reversible expansion again from 100 deg. to 230 deg. C., but no increase in expansion between 550 deg. and 600 deg. C. The cooling curve differed very little from the heating curve, a permanent expansion of 0·06 per cent. being noted. The specific gravity (2·33) confirmed the conversion of the quartz into cristobalite, while the refractive index test showed that a trace of tridymite and a trace of quartz (or silicates) were associated with the cristobalite. Flint fired at about cone 20 for two hours (after previous firing at cone 13–14) behaved very much as before, but had a greater expansion between 100 deg. and 230 deg. C. The material was entirely cristobalite, and, except isolated grains, nothing else was revealed by the refractive index tests. Probably the more rapid conversion of flint—as compared with ganister and quartzite—into cristobalite was due to its physical state, very small crystals being embedded in colloidal silica. There are, however, other possible causes, such as fineness of division.

Sample A, of a commercial silica brick, made from the Bwlchgwyn quartzite, showed a very large coefficient of expansion from 15 deg. to 250 deg. C., followed by a much smaller, but regular, expansion to 550 deg. C. (Curve A, Fig. 4). Thence up to 600 deg. C. the rate of expansion was notably increased. Between 600 deg. and 750 deg. C. there was a small coefficient of expansion, followed by a slight contraction up to 1,000 deg. C. The large expansion associated with inversion of the cristobalite made the expansion of the brick from 15 deg. to 1,000 deg. C. more than double that of a fireclay brick. It would need slow and careful heating with no rigid ties when the structure was first heated, and would be liable to cracking and opening-out of the brickwork if the furnace, &c., had to be let down below 300 deg. C. The specific gravity of the brick was 2·40, and microscopic examination of the powdered brick showed it to consist of quartz and cristobalite with no tridymite.

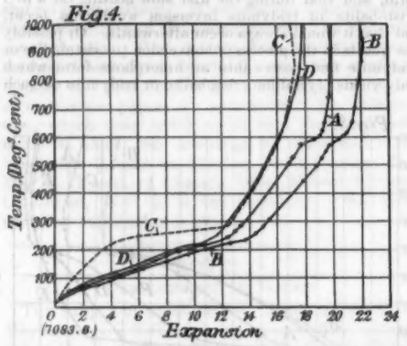
Sample B, of a commercial silica brick, made from the same quartzite as sample A, but containing 25 per cent. of quartzite flour, gave (Curve B, Fig. 4), an expansion-temperature curve similar to sample A, but showing greater expansion from 15 deg. to 250 deg. C., and less expansion from 550 deg. to 600 deg. C. This result agreed with that obtained for quartzite flour fired at cone 9.

Sample D, of a commercial silica brick made from quartzitic pebbles (Yorkshire), showed (Curve D, Fig. 4), in the expansion test that all the quartz had been apparently converted into other forms of silica. The specific gravity was 2·35, and the refractive indices of the particles of powdered brick showed that it was mainly cristobalite with a little tridymite and probably some silicate material, but no quartz.

Silica brick after use in a coke oven for fourteen months, Fig. 5, at a probable maximum temperature of 1,450 deg. C., showed four fairly distinct layers. The innermost layer, about $\frac{1}{16}$ in. thick, was greyish black with large distinct white grains, and a brownish-black outer crust. The next layer, 1 in. thick, was light brown. The third layer, an inch and a-half thick, was dark brown, and the fourth layer, about an inch thick, was light brown, and looked like unaltered brick. The expansion curve for the material of the innermost black contaminated layer was such as might be expected from a contaminated quartz glass, and the total expansion was only half that of the layers behind it. The results of microscopic examination by refractive index would suggest that about half the material was cristobalite, the rest being quartz and silicates of higher refractive index, but the expansion test gave no indication of either cristobalite or quartz. The composition of the material in the layer can be expressed empirically by R O, 0·4 Al_2O_3, 14·3 SiO_2. The partially fused outer crust was doubtless richer in basic material including ferric oxide. The expansion temperature curves for the other three parts of the brick were practically identical, and the actual expansion from 15 deg. to 1,000 deg. C. was in each case almost the same as that for the unused silica brick. The character of the curves was somewhat different from that of the unused brick, there being a rather more rapid expansion from 15 deg. to 150 deg. C. and practically no sudden expansion at 550 deg. to 600 deg. C., whilst above 600 deg. C. the specimens continued to expand, whereas the unused silica brick contracted slightly above 700 deg. C. The long heating had apparently completely transformed the original quartz of the brick. The refractive index of the material of these layers indicated cristobalite associated with a little tridymite and quartz or silicates of higher refractive index. The expansion from 15 deg. to 1,000 deg. C. of the outer darker layer was only about one-half that of the rest of the brick, so that temperature fluctuations would cause great strain to be set up between these two parts of the brick, with consequent cracking off of the inner darker layer.

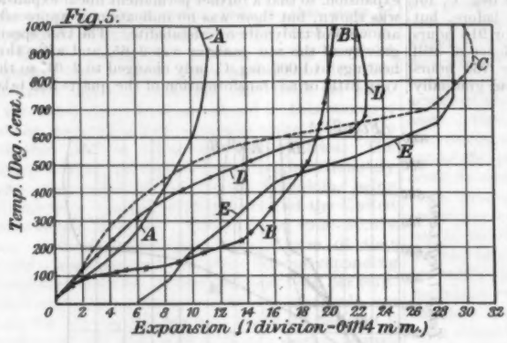
Silica brick, after use in the roof of a steel furnace for 12 weeks, at a probable maximum temperature of 1,600 deg. to 1,650 deg. C., showed four fairly distinct layers Fig. 6: (A) Innermost layer with face exposed in the furnace: A test-piece of this expanded steadily from 15 deg. to 240 deg. C., Fig. 7, and from this point to 280 deg. C. a large and rapid expansion took place. From 280 deg. to 630 deg. C. the rate of expansion was less than from 15 deg. to 240 deg. C., and beyond 630 deg. C. the coefficient of expansion continually decreased until no further expansion occurred between 900 deg. and 1,000 deg. C. The large expansion from 240 deg. to 280 deg. C. was reversible on cooling, but occurred at 220 deg. to 200 deg. C. Apparently neither quartz nor tridymite was present in quantity. Microscopic examination by refractive index showed that the material was mainly cristobalite, but about one-eighth of the powder probably consisted of silicates, and a small quantity was probably tridymite. (B) Second layer: A test piece of this part of the brick expanded steadily and at a fairly rapid rate to 300 deg. C., after which the rate of expansion decreased gradually with increasing temperature until there was a slight contraction between 900 deg. and 1,000 deg. C. The cooling curve was similar to the heating curve. No marked discontinuity occurred. The total expansion to 1,000 deg. C. was about four-fifths, and that from 15 deg. to 300 deg. C. about three-fifths, of that of the hottest (innermost) layer, indicating the possibility of strains and cracks being developed. Microscopic

Fig. 4.



A. Commercial silica brick made from Welsh quartzite. B. Ditto, but containing 25 per cent. silica flour. C. Brick A after twelve weeks' use in gas-port of steel furnace. D. Commercial silica brick from quartzitic pebbles (South Yorkshire).

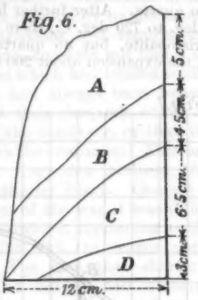
Fig. 5.



Silica Brick A after Use in Coke Oven.

A. Innermost layer near exposed surface. B. Other layers. C. First heating of uncalcined flint. D. Second ditto. E. First cooling of uncalcined flint.

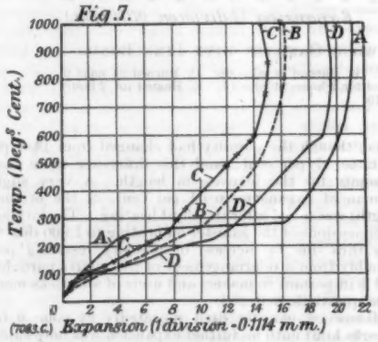
Fig. 6.



Section of Brick from Roof of Steel Furnace.

A. Innermost layer next the exposed face; grey to slaty-black; honeycombed; vitrified; white grains not seen. B. Second layer; black to dark grey, with few large white grains; semi-vitrified and honeycombed. C. Third layer; light grey colour, with large white grains and specks of yellow. D. Fourth layer; reddish in colour.

Fig. 7.



Silica Brick after Twelve Weeks in Roof of Steel Furnace.

A. First (hottest) zone. B. Second zone. C. Third zone. D. Fourth (coldest) zone.

examination by refractive index pointed to the presence of cristobalite and silicates in nearly equal proportions, with a very small amount of tridymite. (C) Third layer: The total expansion from 15 deg. to 1,000 deg. C. was not very different from that of the second layer, but the form of the curve was somewhat different, and there was evidence of the α to β quartz inversion. Microscopic examination of the powdered material gave similar results to those obtained for the second layer, but taking these in conjunction with the expansion of the test piece it seemed probable that some quartz and less silicates were present along with cristobalite in quantity. (D) Fourth layer: The expansion of a test piece of this did not differ appreciably from that of the unused brick, and microscopic examination of the powdered material also gave similar results to those obtained for the unused bricks, indicating a mixture of quartz and cristobalite with a very small amount of tridymite. C. S. Graham, several years ago, from the microscopic examination of thin sections made from a similar brick, arrived at similar conclusions.

Silica brick from gas-port of steel furnace after 12 weeks' use (Curve C, Fig. 4): This, like the two preceding bricks, was made from the same Welsh quartzite as the sample A brick. The lines of demarcation between the different zones were much less marked than in the brick from the roof of the furnace. The brick was divided into three layers. The expansion-temperature graphs of the hottest and middle zones were identical. They expanded steadily and fairly rapidly to about 220 deg. C., when a large and rapid expansion followed to 280 deg. C. Above this temperature the rate of expansion was smaller, and above 600 deg. C. the coefficient of expansion decreased with increasing temperature until from 900 deg. to 1,000 deg. C. a slight contraction occurred. No evidence of the α to β quartz inversion could be detected. The third layer expanded similarly, but the actual expansion was slightly greater. In each case the large and rapid expansion between 220 deg. and 280 deg. C. was reversible on cooling, but occurred 20 deg. to 30 deg. C. lower than on heating. In each case microscopic examination of the powdered material showed that about two-thirds of it was cristobalite, the remainder probably consisting mainly of silicates.

The volume changes in manufacture and use of a silica brick are traced as follows by the authors of the paper: First, on firing, the quartz undergoes a permanent linear expansion, with little or no decrease in specific gravity, but an increase in porosity. This permanent expansion may be about ½ per cent. even below 1,000 deg. C. and considerably more at cone 9. The toughness may appreciably alter in consequence. The further firing to cone 14–16 alters the expansion curve, changing the quartz completely or partially, according to the nature of the raw material and the time and temperature of firing, into cristobalite. This means that the sudden α to β quartz expansion between 500 deg. and 600 deg. C. is replaced by the α to β cristobalite expansion between 200 deg. and 300 deg. C. The total reversible expansion is not lessened thereby. The furnace of "cristobalite" bricks is therefore much less subject to expansion strain at dull redness than one of "quartz" bricks, although more so below 300 deg. C. Neither is it at all sensitive above 600 deg. to 1,000 deg. C. Long exposure in use at high temperatures completes the conversion of quartz to cristobalite. Apart from actual test in the expansion apparatus, the authors have found that a determination of the true specific gravity of the powdered brick is the best guide to its behaviour as regards expansion and contraction.

Appended to the paper are tables of analyses, porosities, specific gravities, and coefficients of expansion, as well as a number of temperature-expansion graphs. The latter—of which those most important in connection with industrial operations are here reproduced—show at a glance the chief results obtained with the materials named under the conditions specified.

Gas Firing.

The concluding discussion took the form of a symposium on gas firing. Sir Arthur Duckham spoke of some of the difficulties of gas-firing and the necessity of training men specially for the work. Dr. E. W. Smith was convinced of the advantage of oil over direct coal firing, but coal being the natural fuel of the country producer or coal gas should be used rather than oil. In all cases the best results were obtained with quick perfect combustion.

Annual Dinner.

This function took place at the Holborn Restaurant on the 6th inst., and was very successful. Sir Arthur Duckham spoke about the present trade crisis, and Mr. A. E. Broadberry pleaded for support of the British Refractories Research Association.

COKE AS A FUEL FOR COMMERCIAL VEHICLES.*

By Thomas Clarkson, Past-President.

Just as it is generally considered a good rule when travelling to drink the "wine" of the country, so in motor transport the rule should be to use as far as possible the fuel of the country, or the particular part of the country, where the transport is needed, in preference to employing an imported fuel which must almost necessarily be more expensive, for example, the so-called "white coal" (water power) of Scandinavia, which is now utilised so effectively for industrial purposes. Again, improved transport facilities are needed for the development of many countries with no water power and which do not yield either coal or oil, but which have abundant supplies of wood from which charcoal can be readily made. Excellent charcoal is made in a primitive fashion by the natives in many places at a cost not exceeding 1*l.* per ton, which is equivalent to petrol at less than 6*d.* per gallon.

Contrast this simple method for the preparation of an efficient transport fuel from material found on the spot, with the difficulties in the production of motor alcohol. We are informed by the alcohol experts that systematic cultivation in the tropics of sago palms, mawrha trees, or other sources of alcohol, could supply the world with all the motor spirit necessary. The carrying out of this apparently simple proposition has been found to involve very serious practical difficulties, of which the following may be mentioned:—

(*a*) The big capital expenditure in preparing and cultivating extensive plantations.

(*b*) The lack of revenue for several years before the plantations become fruitful.

(*c*) The cost of making and maintaining hundreds of miles of roads, and the organisation of transport for collection of the crops and delivery to the distilleries.

(*d*) The cost of building and equipping distilleries.

(*e*) The need for an abundant supply of water for the distilleries.

(*f*) The problem of obtaining the necessary labour for the plantations and distilleries.

(*g*) The problem of denaturing the spirit in order to protect the revenue from loss.

These are some of the difficulties which have prevented the production of alcohol, as a competitor of petrol, even in countries where petrol costs 5*s.* per gallon. Obviously, the chances of alcohol as a motor fuel are quite hopeless against charcoal which can compete with petrol at 6*d.* per gallon, and for the production of which material is available on the spot without special cultivation, without the need for costly distilleries and abundant water supply, and under far easier conditions as regards labour supply and supervision.

In the preparation of this paper, the author has found it desirable to treat the subject more expansively than might naturally be inferred from the title, but he feels that the importance of the subject justifies that course. He has dealt at some length with the subject of charcoal, which is the natural motor fuel of many countries, in tropical as well as in more temperate latitudes, because charcoal, or carbonised wood, is a direct parallel to coke or carbonised coal.

Heat Values of Various Fuels.—The first consideration in judging of the merits of a fuel is the calorific value, or in other words, the amount of heat—measured in British thermal units (or in the number of pounds of water raised 1 deg. F.)—developed by the combustion of 1 lb. of the fuel. This is the only effective standard for comparing the relative heat values of fuels.

We should next compare the prices at which the fuels are obtainable, and in this manner we can readily reduce the net cost of the heat value obtained in the combustion of the various fuels as set out in Table I.

Table I.

Fuel.	Calorific Value in B.Th.U.	Approximate Price.	Approximate B.Th.U. Obtainable for 1*d.*
Petroleum spirit	18,000 per lb.	2*s.* 6*d.* per gallon	4,000
Alcohol	12,400 ,,	2*s.* 6*d.* to 5*s.* per gallon	1,500–3,000
Paraffin	19,000 ,,	1*s.* 3*d.* per gallon	10,000
Benzole	17,300 ,,	2*s.* 3*d.* per gallon	4,000
Coal gas ..	500 per cub. ft.	5*s.* per 1,000 cub. ft.	8,000
Anthracite ..	15,000 per lb.	60*s.* per ton	46,000
Coal	14,112 ,,	50*s.* ,,	52,000
Coke	12,000 ,,	30*s.* ,,	74,000
Charcoal	12,000 ,,	40*s.* ,,	55,000
Creosote oil ..	16,050 ,,	7*d.* per gallon	20,000
Heavy petroleum	17,390 ,,	5*d.* ,,	34,000

The number of British thermal units obtainable for a penny is, of course, subject to market fluctuations.

The number of British thermal units obtainable for a penny is, of course, subject to market fluctuations.

In this connection the author would like to quote from a communication which he recently received from an engineer writing from Sydney:—

"Australia is peculiarly isolated as regards its liquid fuel supplies, being almost wholly dependent on the U.S.A. and Borneo. A small quantity of shale oil is manufactured locally, but it is a negligible quantity.

"Fine coalfields exist in the coastal areas, and abundance of coke and charcoal is obtainable throughout the country. In spite of the cheapness of coke and charcoal, petrol lorries do most of the road transport, but at a cost of ten times that at which a coke-burning lorry, and six times that at which a charcoal-burning lorry could do it.

"No country is in greater need of cheap road transport than Australia, and no country has its splendid natural resources less developed and exploited. True, we have traction engines and steam wagons, but they are only suitable for heavy haulage, and are no great credit to the originality of their designers and builders, as they are so clumsy, and cling to the traditional and conservative lines.

"Benzine costs here 30*s.* per case of 8½ gallons. Taking it as having a specific gravity of 0·740, and having a thermal value of 21,000 B.Th.U. per pound, it costs 5·807*d.* per pound, and we get 3,616 B.Th.U. for 1*d.* Coke costs on an average 20*s.* per ton; taking it as having a thermal value of 14,000 B.Th.U. per pound, we get 2·933 lb. for 1*d.*, and 130,660 B.Th.U. for 1*d.* Take the petrol lorry as using 0·65 lb. per brake horse-power per hour, each horse-power-hour will take 13,650 B.Th.U. Take the coke lorry as using 3 lb. of coke per brake horse-power per hour, each horse-power-hour will take 42,000 B.Th.U. Charcoal can be had for 40*s.* per ton. Considered on a sound economic basis, the petrol lorry has no hope of competing with the steam lorry—it happens just now to be in the fashion. While we are talking loudly of economy and the need of up-to-date service, we are wasting our money by buying expensive fuel from a foreign nation. To be up to date is to have sound economy, and it is not economy to pay ten times too much for our fuel. The public attitude is peculiar—money can be subscribed to float a company whose object is to grow sago palms in New Guinea and extract alcohol from them for use in internal-combustion engines—a rather fantastic scheme at its best, yet it is hard to get the public interest in the development of a machine to utilise the splendid fuel we have right at our doors."

The observations of this Australian engineer apply very forcibly to the conditions in this country. It is only too true that we are to-day not utilising our own natural transport fuels to anything like their full capacity, and we are in consequence losing substantial economic advantages which could be easily realised.

The natural fuel of this country is coal, and its derivatives—coke, gas and creosote oil. Coke is produced generally in two forms: gas coke and oven coke, which is designed primarily for metallurgical purposes, and in which care is taken to remove sulphur and incombustibles as far as possible before it is coked. This is a high grade solid fuel, and at 30*s.* a ton as now quoted yields by far the largest number of thermal units obtainable for 1*d.* in this country, namely, 74,000, as compared with 4,000 thermal units obtainable from 1 lb. of petrol at 2*s.* 6*d.* per gallon. In other words, the number of thermal units obtainable in coke is 18 times the number obtainable in petrol per unit of cost, though it is necessary to take into consideration the difference in the thermal conditions between internal and external combustion. The author desires to be quite fair, even generous, to the internal-combustion method, by assuming that the external-combustion motor requires an expenditure of twice the number of thermal units in order to produce the same mechanical power. Under actual working conditions, as will be shown later, this allowance appears too generous to the internal-combustion motor.

The Use of Coke as a Motor Fuel.—It is important that the coke should be broken to fairly uniform size for use as a motor fuel, the maximum size being 2 in. and the minimum ½ in. For gas coke, which burns more freely than oven coke, the dimensions may be slightly larger. In gas coke there is a larger percentage of ash than in oven coke, and it is important to consider what happens to this ash under the conditions of combustion on a motor vehicle. Some of the heavier ash descends by gravity into the ash pan, assisted by the vibration of the vehicle, the spacing between the bars being wide enough to facilitate this descent. For vehicles operating on rubber tyres the space between the bars should be ½ in. or ⅝ in.—for short distance journeys the spacing may be reduced to ⅜ in. or even ¼ in. When charcoal is employed, the spacing should not exceed ½ in., otherwise too much of the charcoal will be lost through the fire-bars. Some of the ash from the combustion of coke is cintered by partial fusion, forming what is commonly called "clinker." If fusion takes place at a high temperature, the clinker is hard and non-porous and greater in quantity. By burning the fuel at a lower temperature less clinker is produced, and such clinker is sufficiently porous to allow the passage of air through it. By suitable conditions of combustion it is now practicable to run journeys of 100 miles without the necessity of clinkering.

In order to secure a low-combustion temperature, the best results are obtained by using a water-jacketed fire-box instead of a brick-lined fire-box. In the former case there is the advantage of additional heating surface. When a brick lining is used for the fire-box, not only is heating surface lost, but chemical action takes place between the firebrick and the ash, forming a fusible slag, which rapidly corrodes the brickwork and necessitates periodic renewals. This is a distinct drawback, not only on account of the cost of material and labour involved in the renewals, but also of the loss of time during which the vehicle is out of service.

Some of the ash is extremely light both in weight and colour, and is carried upwards from the fire by the draught. Most of this ash, which is as fine as flour, is carried away through the flue, but some of it adheres to the heating surface of the boiler, from which it should be removed by a steam jet every 200 miles or so.

Influence of Moisture in Coke.—It is important to recognise that all coke, except when incandescent, contains moisture, which is accounted for by the porous character of the fuel and the fact that it is frequently stored in the open and exposed to weather conditions. The percentage of moisture varies from 1½ per cent. to

* Paper read before the Institution of Automobile Engineers, on Thursday, October 20, 1921.

15 per cent. From the user's point of view, it is important to buy the coke as dry as possible, as it is obvious that with 10 per cent. of moisture in a reputed ton of coke there is actually only 18 cwt. of fuel. The presence of the moisture is not only a disadvantage when purchasing the coke, but it has been a source of trouble in the past by reason of its tendency to corrode the steelwork of the boiler. When the author began to experiment with coke some years ago he found what others had discovered, namely, that the moisture evaporated from the fuel condensed on the cold parts of the boiler, and the trace of sulphur in the coke when burnt combined with the wet surface of the steel, forming dilute acid, which rapidly corroded the steelwork. An effective remedy was soon found for this by making a rule of starting the fire in a cold boiler by a bucket of incandescent coke and adding no cold coke until the boiler got hot.

When a coke-fired lorry is in regular daily service, it is customary to leave the residue of unburnt fuel, ash and clinker in the fire-box overnight, the heat of which is conserved, and as a consequence the boiler will be warm next morning, and may even have a pressure of 20 lb. or 30 lb. of steam; the author has known cases where as much as 100 lb. pressure remained in the morning. Under such conditions it will be recognised that there is no chance of condensation of moisture from the fuel, and, as stated above, there is no trouble from corrosion by adopting the simple rule of using only incandescent coke when starting a fire in a cold boiler.

The more efficient utilisation of coke as a motor fuel has been strenuously investigated by the author during the past eight years, and as a result very considerable developments and improvements have been made. The following points may be quoted from the report of the Technical Committee of the Royal Automobile Club on the trial of a 3-ton lorry to the author's design carried out by the club in 1914. The gross running weight was 6 tons 11¼ cwt., the net load carried being 2 tons 15½ cwt. The gear ratio was 7·4 to 1, and the diameter of the road wheels 1,050 mm. Over the road between London and Brighton, *via* Redhill, covered twice during the two days, giving a total distance of 109½ miles per day with coke of a calorific value of 12,468 B.Th.U., and of a size which would pass through a 2-in. mesh and be held by a 1-in. mesh, the consumption was found to be 4·08 lb. on the first day and 3·68 lb. on the second day per vehicle mile at a speed of 12 miles per hour; this is equivalent to 1·335 lb. per ton-mile of load carried. The time taken to raise steam from all cold varied from 21½ minutes to 24½ minutes, and one replenishment of coke and one of water was required each day. There were nine stops, chiefly for trimming or re-filling the feed bunkers, throughout the two days, the total time occupied being 55 minutes.

The principal improvements which have been made subsequently are in the adoption of an improved type of boiler, in which the use of firebrick is entirely done away with, which represents a considerable saving both in thermal efficiency and in cost of renewals. Another improvement on the 1914 type of vehicle is a greater simplification of the engine, and the adoption of the standard form of petrol motor transmission, namely, by clutch and gear-box. The engine has only one crank, two cylinders, and two valves, but notwithstanding the fewness of these parts, it gives a torque equivalent to a petrol engine having eight cylinders and 16 valves. Nothing more need be said to emphasise the difference in cost of engine maintenance.

A lorry of the new design (type "X") has been submitted to a trial of 1,000 miles under ordinary service conditions by the South Metropolitan Gas Company in the retail delivery of coke from house to house, necessitating frequent stops and long waits; the weight of fuel used per ton-mile of useful load was found to be 2·02 lb., included in which is the coke required for raising steam each morning.

It is common knowledge that coke is used quite successfully on many of the heavier types of steam lorries, but the experience gained with the Clarkson type "X" during the past five years has demonstrated that coke can be used for long-distance express transport, which hitherto has been considered outside the capacity of steam vehicles, and suitable only for petrol lorries.

In connection with the use of steam vehicles for long-distance transport, the question of water-replenishment has to be considered. The ordinary type of steam lorry takes a charge of approximately 170 gallons of water, which suffices for a journey of 25 miles; the actual distance run between replenishments is usually considerably less than this, owing to the absence of any recognised attempt to provide suitable replenishing stations on our main roads. It is of the highest importance for the proper development of steam road transport that our main roads should be equipped with suitable water-replenishing stations at intervals of from 20 miles to 25 miles. A replenishing station need only consist of a 1,000-gallon tank, elevated on a suitable staging so as to give good head, a canvas hose of not less than 2 in. diameter, and a plug valve. By this arrangement a lorry could be replenished with water within 5 minutes, whereas under the present "happy-go-lucky" arrangement half-an-hour or more is usually wasted. This means not only a loss of time, but of the fuel which is burnt during the period of waiting, and it also means that the daily mileage of the ordinary type of steam lorry might be considerably increased by the installation of suitable watering facilities.

The author is a strong believer in the advantages of condensing the exhaust steam so as to reduce the weight of water to be carried, and to have the advantage of using clean water all the time, which means not only less labour in boiler cleaning, but saving of fuel owing to the better average condition of the boiler.

The utilisation of highly superheated steam, and a good ratio of expansion in the cylinders, has reduced the weight of steam used per horse-power very considerably; simultaneously, the improvement in condenser construction has increased its capacity, and as a result it is now possible to condense practically the whole of the exhaust. Not only so, but under average conditions of running a small vacuum is obtained which further helps in the general efficiency of running. Where a condenser is used it is, of course, essential to remove from the water of condensation all traces of oil used in the lubrication of the cylinders. The greater portion of this oil can be removed by ordinary filtration, but unfortunately a portion of the oil will emulsify in the water, and the emulsified oil is not amenable to ordinary filtration. The emulsified oil can, of course, be removed chemically, but this is out of the question under the conditions. It has, however, been discovered that by passing the water containing emulsified oil between iron plates through which a slight electric current is passing, the constitution of the emulsion is so changed that it can be completely removed by ordinary filtration. The development of electric lighting for motor vehicles here comes in very useful, and the small amount of current (less than 1 ampere) required for the removal of the emulsified oil can easily be obtained from this source. The apparatus needs no attention except the renewal of the iron plates every two years. The oil removed from the filter can be used for the general lubrication of the chassis, thus effecting further economy in operating costs.

The Use of Coke in Portable Gas Producers.—In considering the use of coke as a fuel for commercial vehicles, recognition should be given to the work of D. J. Smith, Parker, and others, in the development of a portable gas producer, and it is possible that for some kinds of transport where the conditions are favourable, this may prove to be a valuable method of using coke. The gas producer on a large scale is accepted as an efficient appliance, but producers of the small dimensions required for use on motor lorries necessarily lose some of the advantages possessed by their big brothers. The large producer has a good "flywheel" effect, and the fire is not liable to go out if the engine is stopped for an hour, whereas with the small portable producer the author is informed that there is risk of this happening if the engine is stopped for about 10 minutes. In order to prevent this it is necessary for the driver to blow up the fire, or keep his engine running, which is a disadvantage from the point of view of personal attention and fuel economy.

The starting of the engine of a gas producer also leaves much to be desired. The author has observed that much cranking is frequently necessary before gas of a suitable quality is obtained. It should also be borne in mind that the heat generated in the gas producer by the first stage of combustion in order to convert solid carbon into carbon-monoxide is practically wasted. This amount of heat represents 26·6 per cent. of the total heat developed in the complete oxidation of carbon to carbon-dioxide. In this respect the steam boiler has an advantage, as it is able to utilise the heat yielded in the first as well as in the second stages of oxidation.

There appears to be little to choose between the weight of the gas producer plus the extra weight of its engine and the weight of the engine and boiler of the steam set, but on the other hand, the last-named unit is simpler, is more flexible, and is capable of responding quickly to a sudden demand for power. It is also more easily understood, and requires less attention. The time required to prepare the gas producer for service offers no advantage over that for raising steam. Another drawback to the gas producer is the necessity for using firebrick lining instead of a water jacket, since the firebrick rapidly deteriorates and must be renewed every few months.

In the gas producer lorry the consumption of best quality oven coke carefully graded to 1 in. size is about 3 lb. per vehicle-mile for 100 mile run on a 3-ton lorry, fully loaded. It is interesting to compare this consumption with the 3·68 lb. of ordinary gas coke consumed per vehicle-mile for a 3-ton steam lorry fully loaded over a distance of 109½ miles.

Conclusion.—It must be recognised and admitted that when coke is used as a motor fuel, either for raising steam or making gas, the cost of transport may be very considerably reduced as compared with the petrol motor.

Petrol at 2*s.* 4*d.* per gallon costs 4*d.* per vehicle-mile when operating a 3-ton lorry at 7 miles per gallon—which may be taken as a fair and even generous mileage allowance. Compare this with the performance of coke-fired vehicles—(*a*) steam, and (*b*) gas producer.

(*a*) *Steam.*—Taking the average consumption on a journey of 100 miles at 4½ lb. of coke per mile, with coke at 40*s.* per ton, this represents a fuel cost of 1*d.* per vehicle-mile.

(*b*) *Gas Producer.*—Assuming the consumption to be 3 lb. of coke, the cost for fuel would be two-thirds of a penny per vehicle-mile.

To this must be added the extra cost of maintenance of the producer and engine, which the author is convinced would give a net result showing a substantial balance in the cost of operation to the credit of an up-to-date steam vehicle using coke as a motor fuel.

Australian Standard Specifications for Rails and Fishplates.—His Majesty's Senior Trade Commissioner in Australia (Mr. S. W. M. McGregor) has transmitted to the Department of Overseas Trade a copy of the Australian standard specifications for rails and fishplates issued by the Institute of Science and Industry, which the various railway authorities in Australia have agreed to adopt for their specifications. This publication may be inspected by United Kingdom firms interested, on application to the Inquiry Room, Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1.

ADMIRALTY GUN-METAL.

*The Effect of Increasing Proportions of Lead upon the Properties of Admiralty Gun-Metal. With an Appendix dealing with the Effect of Lead on Gun-metal containing Copper 85 per cent., Tin 5 per cent., Zinc 10 per cent.**

By R. T. Rolfe, F.I.C., Member (The Metallurgical Research Laboratory, Messrs. W. H. Allen, Sons & Co., Ltd., Queen's Engineering Works, Bedford).

The effect of lead in this alloy has been previously dealt with by H. S. Primrose, J. Dewrance, F. Johnson, and the present author.

Primrose's experiments were on chill-castings, the influence of this impurity being studied up to a proportion of 3 per cent., the lead replacing an equivalent weight of copper. Lead was added to normally fine gun metal. Casting temperatures, etc., were not given.

Dewrance's work dealt with greensand castings, the addition of lead being carried as far as 16 per cent., always at the expense of the copper. Dewrance claimed for leaded gun-metal an increased resistance to the action of high temperatures as compared with the lead-free alloy, and stated that gun-metal containing 0·5 per cent. of lead could be used without loss of strength up to 550 deg. F., while with the material of normal composition an enormous falling off, both in strength and ductility, occurred at a temperature of about 400 deg. C. As the results obtained by the Admiralty with the same two alloys do not confirm this contention, the matter is, however, still in some doubt.

Johnson's results were from small chill-castings.

From a study of these papers in particular, and from the general literature on the subject, it appeared that, in spite of the previous work, the exact effect of lead in gun-metal was still quite uncertain. This opinion was confirmed by a consideration of the following varied opinions, extracted mainly from the papers in question, or from the discussions thereon:—

F. Johnson: "Lead does not appear seriously to affect the mechanical properties, although it is possible the resistance to shock is lessened."

H. S. and J. S. G. Primrose: "It has even been claimed that with half of 1 per cent. of lead in gun-metal the tensile strength of the alloy is improved, but this is very doubtful."

W. Ramsay: "Even 0·5 per cent. of lead would reduce the tensile strength very materially."

A. E. Seaton: "At one time lead was looked upon as a public enemy, but now everybody was proving what a good friend it really was."

The author: "The author has also found that 1 per cent. of lead does not affect the quality appreciably."

Owing to this uncertainty, it was decided to carry out a further series of tests on the same lines as in the case of the antimony and arsenic investigations previously published (see Engineering, Vol. cx., pp. 689 and 752).

A number of synthetic alloys were prepared, showing a progressive increase in the proportion of lead, both sand- and chill-castings being made side by side, while casting temperatures were determined, and complete analyses were made of all the different compositions, these being correlated with the mechanical test results, soundness of castings, hardness, Stanton impact values, and with the microstructures. Apart from the complete analyses of all the alloys, complete analyses were made of all the original constituent metals used.

In the case of each alloy, the residual metal from each melt, after the requisite sand- and chill-cast bars had been poured, was cast into ingots. These were later re-melted, without any addition being made, and further bars were cast, while again casting temperatures were determined and analyses made. This procedure afforded an additional check upon the influence of the lead, and also gave information as to the variation in composition caused by re-melting. The approximate proportions of lead aimed at were, respectively, none, 0·5 per cent., 1·0 per cent., and 1·5 per cent. The descriptions and analyses of the copper, tin, lead, and zinc, respectively, that were used are subjoined:

Copper	...	Rio Tinto Best Selected.
Tin	...	Messrs. Williams, Harvey and Co.'s "Lamb and Flag" Brand.
Lead	...	Messrs. Quirk, Barton and Burns, St. Helens, Brand as stated.
Zinc	...	Messrs. Suzuki and Co.'s "Rising Sun" Brand.

The respective analyses of these metals were as follows:

Table I.—*Analyses of the Components.*

—	Rio Tinto Copper.	"Lamb and Flag" Tin.	Quirk, Barton and Burns' Lead.	Suzuki and Co.'s Zinc.
	per cent.	per cent.	per cent.	per cent.
Arsenic	0·46	0·19	—	nil
Antimony ..	nil	0·10	0·08	nil
Tin	traces	99·30	0·14	nil
Lead	0·18	0·07	99·63	0·088
Iron	traces	0·03	0·10	0·014
Bismuth ..	nil	nil	—	—
Sulphur ..	nil	—	—	—
Nickel	nil	0·008	nil	nil
Zinc	nil	traces	traces	99·891
Silver	traces	nil	traces	—
Oxygen, &c. (diff.) ..	0·07	—	—	—
Copper	99·29	0·140	0·05	traces
	100·00	99·838	100·00	99·993

* Abstract of a paper read at the Birmingham meeting of the Institute of Metals, September 21, 1921.

It will thus be seen that the tin, lead, and zinc were of a good degree of purity. The Rio Tinto copper, which was the only brand available at the moment, contained 0·18 per cent. of lead, an exceptionally high figure for this brand. For experiments on the effect of lead, this feature was, of course, of little importance. It also contained 0·46 per cent. of arsenic, which is not unusual in this copper. The result was that all the lead alloys contained nearly 0·5 per cent. of arsenic. As this, however, appeared to lead to no particular falling away in the quality of the nominally lead-free metal, and as exactly the same proportion occurred in each of the leaded alloys, which again showed a

Fig. 1.

FIG. 1. METHOD OF CUTTING UP BARS (BOTTOM IS TO LEFT).

(1) Reserved.
(2) Tensile piece.
(3) Hardness piece.
(4) Micro-piece.

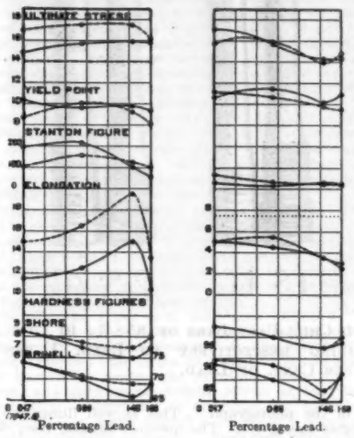


FIG. 3. SAND-CAST.

FIG. 4. CHILL-CAST.

Results from melts shown as full lines; results from re-melts as broken lines. The chain line represents the minimum figure of the Admiralty specification for ultimate stress, and the dotted line the corresponding minimum figure for elongation per cent.

TABLE II.—*Lead Contents and Casting Temperatures of Lead Alloys.*

Melt.				Re-melt.			
Lead Content per Cent.	Mark.	Description.	Casting Temperature, Deg. C.	Lead Content per Cent.	Mark.	Description.	Casting Temperature, Deg. C.
0·17	$A1C_1$ & 2	Chill	1,210	0·18	$B1C_1$ & 2	Chill	1,220
0·17	$A1S_1$ & 2	Sand	1,210	0·18	$B1S_1$ & 2	Sand	1,220
0·86	$A2C_1$ & 2	Chill	1,220	0·91	$B2C_1$ & 2	Chill	1,210
0·86	$A2S_1$ & 2	Sand	1,220	0·91	$B2S_1$ & 2	Sand	1,210
1·46	$A3C_1$ & 2	Chill	1,220	1·48	$B3C_1$ & 2	Chill	1,210
1·46	$A3S_1$ & 2	Sand	1,220	1·48	$B3S_1$ & 2	Sand	1,210
1·68	$A4C_1$ & 2	Chill	1,200	1·67	$B4C_1$ & 2	Chill	1,230
1·68	$A4S_1$ & 2	Sand	1,200	1·67	$B4S_1$ & 2	Sand	1,230

TABLE III.—*Analyses of Lead Alloys.*

Proportion of Lead in Melt of Alloy.	0·17 per Cent.		0·86 per Cent.		1·46 per Cent.		1·68 per Cent.	
	Melt.	Re-melt.	Melt.	Re-melt.	Melt.	Re-melt.	Melt.	Re-melt.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Copper ..	87·72	88·23	87·30	87·84	86·58	87·39	86·23	86·27
Tin	9·97	10·04	10·05	10·00	10·04	9·95	10·12	10·17
Antimony ..	trace	trace	trace	trace	trace	trace	trace	trace
Arsenic ..	0·48	0·47	0·50	0·47	0·48	0·48	0·47	0·49
Iron	0·08	0·05	0·07	0·04	0·06	0·05	0·06	0·06
Lead	0·17	0·18	0·86	0·91	1·46	1·48	1·68	1·67
Zinc	1·54	0·98	1·16	0·72	1·33	0·62	1·42	1·30
Nickel ..	trace	trace	trace	trace	trace	trace	trace	trace
	99·96	99·95	99·94	99·96	99·95	99·97	99·96	99·96

marked variation in properties with the variation in the proportion of lead, it was not considered that the presence of the arsenic could have any masking effect on the true action of the lead.

In the manufacture of the alloys a 50-lb. pot was used, the copper being melted first, the tin and lead being then added, and the zinc last, just before pouring. A pit-fire was used, operated by natural draught. The time of melting, from the start to pouring into the moulds, was approximately 2¼ hours. No flux or other covering material was employed in any case. The size of the bars, both sand and chill, was 1 in. in diameter by 15 in. long. The top 3 in. of each bar was cut off in the foundry, to ensure the removal of any piped material. Four bars were cast from each melt, two sand and two chill. The weight of the metal moulds in which the chill-cast bars were made was 26 lb., and the wall was about ¾ in. thick at the top, increasing to 1¼ in. at the bottom, and about 1½ in. thick in the actual base. These moulds were, as usual, heated before casting in order to get rid of moisture and to avoid unsoundness. They were coated on the inside with boiled linseed oil. The sand-castings were in green-sand.

The details of the different proportions of lead actually obtained in the eight different melts, and the temperature at which the bars were cast, are given in Table II in the previous column.

The casting temperatures recorded were those of the metal in the shank ladle before pouring into the moulds, and were determined by means of a Foster pyrometer (nickel-chromium and nickel), reading to a little above 1,350 deg. C. The accuracy of the instrument was checked each time it was used against both a Féry radiation pyrometer and a Paul platinum, platinum-iridium pyrometer, no variation greater than 10 deg. C. being recorded at the temperatures at which it was operating.

The way in which each bar was cut up for examination is shown in Fig. 1. The complete analyses of all the eight alloys, four from melts and four from re-melts, are detailed in Table III. The respective compositions were thus not seriously altered in re-melting. There is the usual reduction in the proportion of zinc, and rise in that of the copper.

The Effect of Lead upon the Mechanical Test Results.—The figures in Table IV. were obtained for this series of tests. The results as a whole are plotted as graphs in Figs. 3 and 4, compared with the minimum figure laid down by the Admiralty specifications for this material, viz., an ultimate stress of not less than 14 tons per square inch, with a minimum elongation of 7·5 per cent. on 2 in. Fig. 2 shows the sand-cast series bars.

Taking first the results from the sand-cast material, it will be seen that lead up to about 1·5 per cent. progressively increases both the strength and the ductility of the alloys, while above 1·5 per cent. both figures show some falling away. The tendency is shown equally well in both melts and re-melts. As compared with the results from the melts, the re-melted alloys show an improvement in both strength and ductility. It will be noticed that as the ductility increases the Shore and Brinell hardness figures fall away, so as to show a minimum figure at 1·46 per cent. of lead, the point of maximum ductility. The results, which are thus very consistent, are quite different from those of the previous workers, already referred to.

As has been previously seen when investigating the effect of antimony and arsenic, these effects of lead are somewhat masked in the chill-castings. Thus, while the hardness figures of the chill-castings are correlated quite well with those of the sand-castings, the effect of lead, seen in the latter, of increasing the strength and ductility up to 1·5 per cent. is not shown, although there are indications of a turning-point in the ultimate stress curve with this proportion of lead, but associated with a minimum rather than a maximum figure. The ductility, again, appears to show a progressive falling away as the lead increases, the lowest figures of all being obtained with the maximum proportion of lead. These results are thus nearer to those of Primrose.

From the view-point of strength and ductility, there thus appears in the case of sand-castings, no justification for the limiting in the Admiralty specification of the lead content of this alloy to 0·5 per cent. Up to 1·5 per cent. might be allowed. This would result in improved mechanical qualities. As will be seen later, however, there are other considerations, to which due weight must be attached.

The Effect of Lead upon the Soundness of the Castings.—No difference in this respect was observable in the case of either the sand- or chill-cast bars containing the various proportions of lead, all of which were perfectly sound.

The effect of Lead on the Hardness.—Shore and Brinell hardness determinations were made on pieces cut from the same corresponding positions at the top of each bar, as shown in Fig. 1. The plane surfaces on which the tests were made were finished by Hubert's No. 1 emery paper. All Shore figures are a mean of seven determinations, and all Brinell figures a mean of three, with a pressure of 500 kilos. The results obtained are shown in Table IV. and Figs. 3 and 4. The effect of lead is the same in both sand- and chill-castings, gradually reducing the hardness up to about 1·5 per cent. and increasing it again afterwards, this being, as previously

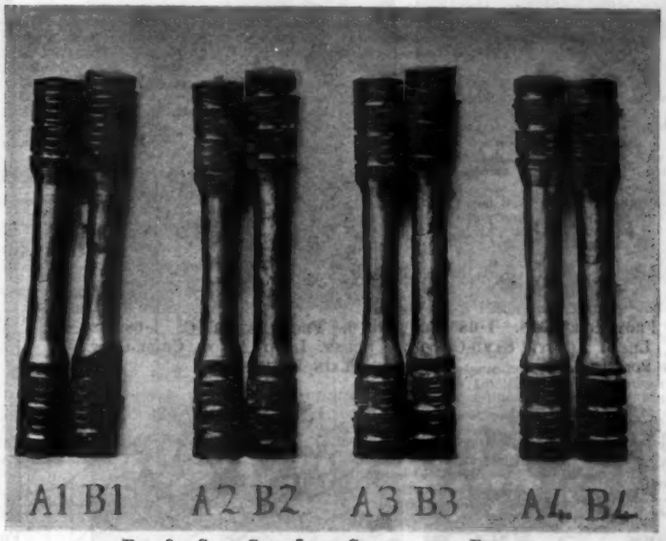


FIG. 2. SAND-CAST LEAD SERIES AFTER PULLING.

TABLE IV.—MECHANICAL TEST RESULTS OF LEAD ALLOYS.

Lead.	Melt or Re-melt.	Casting Temperature.	Marks on Test-pieces.	Sand-Cast Bars.						Chill-Cast Bars.					
				Yield Point.	Ultimate Stress.	Elongation.	Stanton Test Impacts to Fracture.	Hardness Figures.		Yield Point.	Ultimate Stress.	Elongation.	Stanton Test Impacts to Fracture.	Hardness Figures.	
								Shore.	Brinell.					Shore.	Brinell.
per cent.		deg. C.		tons per sq. in.	tons per sq. in.	per cent.				tons per sq. in.	tons per sq. in.	per cent.			
0·17	Melt ..	1,210	A1S & C	10·4	14·8	11·5	191	8·5	74	10·6	17·1	5·0	20	9·0	91·0
0·86	Melt ..	1,220	A2S & C	9·84	15·7	12·5	217	7·0	70	11·44	15·7	4·5	17	8·0	87·6
1·46	Melt ..	1,220	A3S & C	9·8	15·0	15·0	103	6·0	66	10·18	14·3	3·5	31	7·0	82·6
1·68	Melt ..	1,200	A4S & C	9·4	15·8	10·5	59	7·0	69	10·9	14·3	2·5	25	7·5	89·0
0·18	Re-melt	1,220	B1S & C	8·72	17·0	15·0	107	8·5	74	11·14	15·7	5·0	67	9·0	92·0
0·91	Re-melt	1,210	B2S & C	10·08	17·5	16·5	156	7·5	71	10·64	15·9	5·5	33	8·0	91·0
1·48	Re-melt	1,210	B3S & C	9·24	17·6	19·5	127	7·0	69	9·76	13·9	3·5	23	7·0	85·0
1·67	Re-melt	1,230	B4S & C	8·18	16·2	13·5	104	8·0	69	9·56	14·8	3·0	19	8·0	89·0

The sand-cast tensile bars are shown in Fig. 2, above. The chill cast bars are not reproduced.

stated, in the case of sand-castings, correlated with the ductility.

The Effect of Lead on the Resistance to Repeated Impact.—This point has frequently been referred to when the effect of this impurity on gun-metal has been discussed, and it seemed therefore desirable to investigate it. The material available, however, was only one bar of each of the eight alloys, the companion bar to that used in each case for the tensile test. It was, therefore, impossible to carry out any serious tests, which would have required a large number of bars, and several different intensities of loading, so as to yield a curve giving some rough indication of the safe range of stress, or the limiting blow which could be applied repeatedly without leading to ultimate failure. Again, the practical interpretation of even such a curve presents some difficulty, so that it is with very much reservation that the author puts forward the results of Stanton repeated impact tests made under only one set of conditions, and these such as to lead in all cases to a speedy failure of the material being tested. The results are thus only points on Wöhler curves, the exact forms of which are unknown, and can only be regarded as a very rough indication of the shock resistance in so far as the different alloys are really comparable in this manner.

The machine employed was that made by the Cambridge Scientific Instrument Company, using the standard 4½-lb. tup, falling from a height of 2 in., and making 90 impacts per minute. The test-piece used was of 0·5 in. diameter, notched down in the middle to 0·4 in. by a square notch 0·05 in. wide, the corners of the groove having a radius of approximately 0·01 in. The results are shown in Table IV. and Figs. 3 and 4.

It will be seen that in the case of the sand-castings, with both melt and re-melt, a maximum impact figure was associated with the presence of 0·86 per cent. of lead, while the presence of larger quantities of lead caused a progressive falling away in this figure. With the chill-castings, the results from the melt were somewhat erratic, while in the re-melt the highest impact figure was obtained from the alloy most free from lead, increasing lead causing a steady falling away in this value.

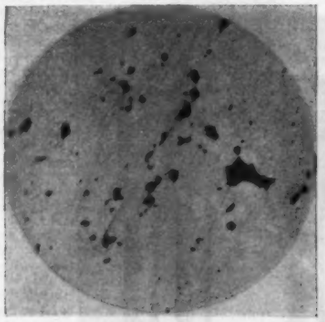


Fig. 5. From Bar A4S. 1·68 per cent. Lead Alloy, Sand-Cast. Plain Polished.

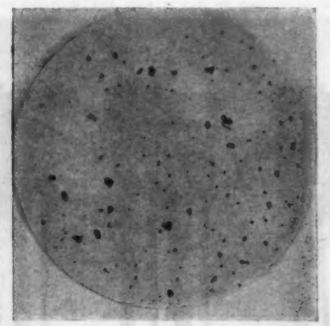


Fig. 6. From Bar A4C. 1·68 per cent. Lead Alloy, Chill-Cast. Plain Polished.

Fig. 7. From Bar A1S. 0·17 per cent. Lead Alloy, Sand-Cast. Etched with Ammonium Persulphate.

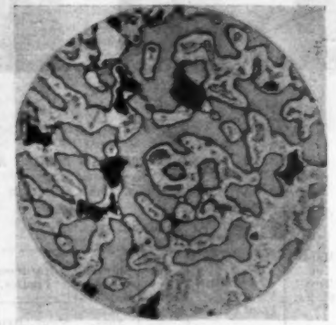


Fig. 8. From Bar A4S. 1·68 per cent. Lead Alloy, Sand-Cast. Etched with Ammonium Persulphate.

Fig. 9. From Bar A1C. 0·17 per cent. Lead Alloy, Chill-Cast. Etched with Ammonium Persulphate.

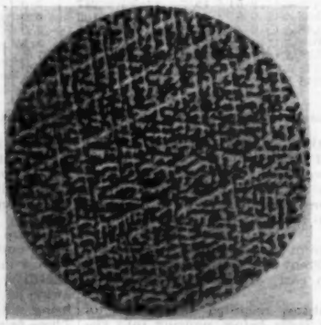


Fig. 10. From Bar A4C. 1·68 per cent. Lead Alloy, Chill-Cast. Etched with Ammonium Persulphate.

Magnification in all Cases 100 Diameters.

of the casing in question. It is thus desirable that the resistance of the metal to repeated impact should be as high as possible. There is again the obvious deduction that a turbine-driven circulating water-pump, in which this fluctuating effect could not occur, is much more suitable than a reciprocating engine for the purpose in question. Turbines are, of course, supplanting steam engines for this purpose, but many of the latter sets were in use during the war and are probably still to-day.

From these tests, it will be seen that in the case of sand-castings of this alloy, but not with chill-castings, the addition of 1 per cent. of lead could be recommended, in order to increase its resistance to repeated impact. As sand-castings constitute practically the whole of the castings made and used for any purposes where repeated impact enters into the case, the fact that in chill-castings increasing lead appears to cause a steady falling off in the impact resistance is not of great moment.

The Effect of Lead on the Microstructures.—This has been discussed by previous workers. It is, for example, well known that in Admiralty gun-metal, phosphor-bronze, plastic bronze, and similar alloys, practically all the lead separates out when the metal is solid, and can be readily observed in a polished specimen that has not been etched as a number of dark and more or less rounded inclusions scattered irregularly through the matrix. Further, as has been already stated by Law, these lead inclusions are frequently "torn out in the process of polishing, leaving pits which appear as black dots in the photograph." This is well illustrated by the figure Law gives. The question has also been dealt with by Gilligan and Curran.

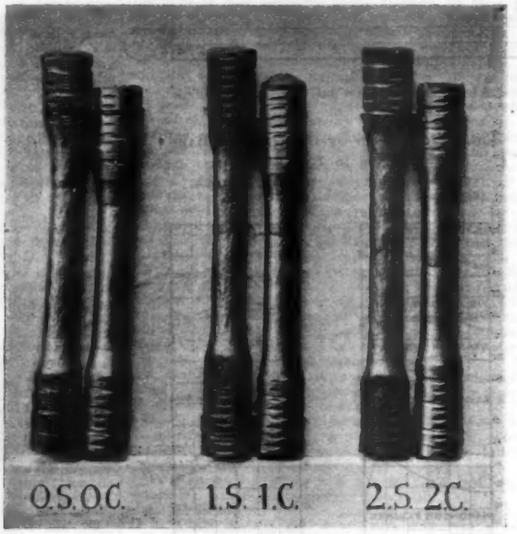


Fig. 11. Sand and Chill-Cast Bars of 85 : 5 : 10 Gun-Metal containing respectively no Lead, 1 per cent., and 2 per Cent. of Lead.

On account of this separation of the lead, it is possible by a planimetric determination, by making due allowance for the specific gravity of the lead, to estimate approximately the proportion of this impurity present in a particular alloy. This, of course, varies in different parts of the same casting, owing to segregation of the lead. For example, in the 1·68 per cent. sand-cast alloy, the author found, by this method, proportions of lead varying between 1·08 per cent. and 3·26 per cent., the average figure approximating to that returned by analysis, viz., 1·68 per cent.

These small particles of lead are associated with and set in the eutectoid. The result of this is that, since in a chill-blast gun-metal the eutectoid particles are much smaller and more evenly distributed than under the conditions of slower cooling obtaining with sand-cast metal, so in the chill-cast alloy are these particles smaller and more evenly distributed than in the other case.

This is illustrated in Figs. 5 and 6. The former shows, at a magnification of 100 diameters, a plain polished section of A4S, the alloy containing 1·68 per cent. of lead, sand-cast. The same alloy, chill-cast, and photographed under the same conditions, is given as Fig. 6. In the latter case the lead segregates are smaller and more evenly distributed through the matrix. The other alloys show the same features, but with the lesser proportions of lead.

The normal structure of gun-metal is best developed by etching with a saturated solution of ammonium persulphate. Fig. 7 shows the microstructure of A1S, the sand-cast alloy containing 0·17 per cent. of lead, and Fig. 8 that of A4S, the 1·68 per cent. lead alloy, both at a magnification of 100 diameters. These show in each case the light matrix of primary α, the areas of secondary α as isolated and as ramified areas separated from the primary α by well-marked boundaries, while the eutectoid and lead areas are inset in the secondary α, the former, when free from lead, appearing as the usual speckled constituent, with angular outlines, while the lead segregations, or more frequently the cavities left therefrom, are dark, rounded, and somewhat featureless.

Fig. 9 shows the microstructure of A1C, the chill-cast alloy containing 0·17 per cent. of lead, and Fig. 10 that of A4C, the 1·68 per cent. lead alloy, at the same magnification as before. The structure of chill-cast gun-metal is not very well resolved at this magnification, and, as the lead segregations are smaller and much more dispersed, they are very much less noticeable than in the case of the sand-cast alloy containing the same proportion of this impurity. The lead may, however, be readily observed on the plain polished specimen, as has been illustrated.

General Considerations regarding the Presence of Lead in Gun-metal.—The chief adverse effect of lead in gun-metal is that owing to the long cooling range of 200 deg. C.

(during which the lead is of course molten, and is, as regards practically the whole of the lead present, merely mechanically contained in the alloy) there is an increased tendency towards segregation of the α-σ eutectoid. Ramsay mentions the extrusion from a heavy casting, containing an average proportion of 0·5 per cent. of lead, of a brittle white constituent containing 6·5 per cent. of lead, and goes on to say, "The extraordinary concentration of the lead was suggestive. It would almost appear as if the tin and lead had combined to form a low melting-point alloy which had sweated out. It might explain the objection to lead in gun-metal."

The author does not know on what grounds the permissible proportion of lead in gun-metal was limited by the Admiralty specification to 0·5 per cent., probably rather on the grounds of general mechanical quality than in view of the somewhat unusual phenomenon referred to. From the present work it will be seen that in regard to strength and ductility the limitation appears unnecessary, for it is only on exceeding a figure of about 1·5 per cent. that any falling away becomes noticeable, while, up to this figure, a steady improvement is obtained. Since the greatest impact resistance appears to be associated with a figure of about 1 per cent., it is here suggested that Admiralty gun-metal might safely contain 1 per cent. of lead without any prejudicial effect, but rather an improvement in the general quality of the castings. The liquation trouble has not been experienced by the author in the case of gun-metals leaded up to 2 per cent. and 3 per cent., even with castings of moderately heavy design. In the case of many large castings, for example, main circulating pumps for battleships, where one may have a casting anything between 10 cwt. and 30 cwt. in weight, but with a maximum thickness of metal in the walls of the casting of possibly only some $\frac{1}{4}$ in., it would be practically impossible, owing to the design of the casting, for such liquation to take place. Under certain circumstances, as has been already seen, it may occur, but where a casting is heavy and of massive section such tendency could be guarded against.

There are one or two other points to consider. One is that of the machinability of the alloy, which it is almost superfluous to say is much improved by the addition of lead. There is further the question of corrosion, in the case of which it is suggested that we have no data to show that the resistance to corrosion might not be increased by the addition of 1 per cent. of lead.

Compare the 2 per cent. lead-brass (Muntz's "Nergandin"), for which, when used as condenser tubes, a considerably increased resistance to the attack of sea-water is claimed than in the case of plain 70 : 30 brass.

If there exist, among the Admiralty records or elsewhere, any data as to definite effects of lead in the direction of accelerating or retarding the corrosion of this alloy, this would appear a convenient opportunity of putting the same on record. Such data would confirm or modify the opinion here expressed.

In the case of gun-metal used for bearings, the increase in the lead would be advantageous. Thus it has been demonstrated by Charpy, by means of compression tests, that in the case of copper-tin-lead-zinc alloys, the addition of lead increases the plasticity of the bronze; while, with similar alloys, W. K. Frank found that the addition of lead gave rise to decreased wear as compared with the lead-free alloys. It would appear a little strange that the presence in a bronze of a number of small particles of a soft and plastic metal having a higher coefficient of friction that the surrounding matrix should lead to decreased wear in a bearing made from the alloy, which decrease wear could presumably only result from decreased friction. Such, however, appears to be the case.

There thus appears to be a good case for increasing the permissible limit of lead in sand-cast Admiralty gun-metal from 0·5 per cent. to 1 per cent. It is clear that the supposed prejudicial effects of lead in gun-metal, have anyhow, been somewhat exaggerated.

Conclusions.—In sand-cast Admiralty gun-metal, the addition of lead up to a certain proportion progressively increases the strength and ductility and decreases the hardness. At a point corresponding to the presence of about 1·5 per cent. of lead, the strength and ductility begin to fall away and the hardness increases. Maximum resistance to repeated impact is obtained from the alloy containing about 1 per cent. of lead, larger quantities causing a progressive falling away in this respect. There is no apparent effect on the soundness of sand-cast gun-metal containing up to 1·68 per cent. of lead. Lead is readily detectable in the microstructure.

In chill-cast gun-metal these effects are somewhat masked. The effect of increasing lead on the hardness is well correlated with that of the sand-cast material, with a change-point at about 1·5 per cent. of lead, but associated with a minimum rather than a maximum strength figure. The ductility shows a progressive falling away as the proportion of lead increases. The same remark applies to the impact figure in the case of the metal melted twice, the results from the metal melted once being much more irregular. There is no apparent effect on the soundness of chill-cast gun-metal containing up to 1·68 per cent. of lead. Lead is not so readily observable in the etched material, but can be quite well detected on the plain polished surface.

Apart from the effect of lead on the mechanical test results, the general considerations regarding the effect of lead are also discussed, including the question of liquation, machinability of leaded gun-metal, corrosion, and behaviour as a bearing metal.

It is suggested that in sand-cast gun-metal, the proportion of lead permitted by the Admiralty specification might with advantage be increased from 0·5 per cent. to 1 per cent.

The author desires to express to Messrs. W. H. Allen, Sons and Company, Limited, his thanks for their permission to publish the results detailed in this paper.

APPENDIX.

The Effect of Increasing Proportions of Lead on Gun-Metal containing Copper, 85 per cent. Tin 5 per cent., Zinc 10 per cent.—In view of the somewhat unlooked-for results obtained from the 88 : 10 : 2 alloy, it was considered that it would be of interest to extend the investigation on the effect of lead to another zinc-tin-copper alloy in common use. For certain purposes the Admiralty alloy must naturally be used, for example for bearings, for discs for high-lift pumps, and for similar purposes where hardness is a desideratum. On the other hand, for general castings where special hardness is not requisite, and where the Admiralty specification has not to be complied with, cheaper mixtures, obtained by decreasing the proportion of tin and increasing that of zinc, may often be substituted with advantage. The result is a progressive slight decrease in the yield point and maximum stress figures, accompanied by an increase in ductility, due to the decrease in the proportion of the hard and brittle δ constituent.

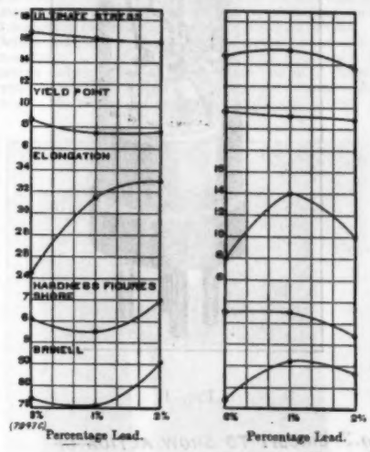


FIG. 12. SAND-CAST. FIG. 13. CHILL-CAST.

The results obtained from some of the author's melts and re-melts of the 88 : 10 : 2, 87 : 8 : 5, and 85 : 5 : 10 alloys, showing the relations between them, are subjoined.

TABLE V.—*Mechanical Test Results of* 88 : 10 : 2, 87 : 8 : 5, *and* 85 : 5 : 10 *Gun-Metals respectively.*

Gun-Metals.			Melt or Re-melt.	Hardness Figures.		Tensile Tests.		
Copper per cent.	Tin per cent.	Zinc per cent.		Shore (Magnifier Hammer).	Brinell.	Yield Point, Tons per sq. in.	Ultimate Stress, Tons per sq. in.	Elongation per cent.
88	10	2	Melt ..	16	77	10·4	17·0	14·0
88	10	2	Re-melt	14	79	9·1	17·0	17·2
87	8	5	Melt ..	18	80	8·3	16·8	18·7
87	8	5	Re-melt	19	83	8·3	15·5	15·6
85	5	10	Melt ..	15	69	7·8	16·0	25·0
85	5	10	Re-melt	15	69	7·7	15·5	23·4

The effect of increasing the proportion of lead in the case of the last alloy was studied by making sand-and chill-castings of the normal alloy, and also by adding respectively 1 per cent. and 2 per cent. of lead in addition. The conditions were otherwise similar to those already described in the case of the 88 : 10 : 2 alloy, while the casting temperatures were all in the region of 1,200 deg. C. The following results were obtained :—

TABLE VI.—*Mechanical Test Results of* 85 : 5 : 10 *Gun-Metal containing Varying Proportions of Lead.*

Lead, per Cent.	Sand-Cast Bars.						Chill-Cast Bars.					
	Yield Point, Tons per Sq. In.	Ultimate Stress, Tons per Sq. In.	Elongation, per Cent.	Hardness Figures.			Yield Point, Tons per Sq. In.	Ultimate Stress, Tons per Sq. In.	Elongation, per Cent.	Hardness Figures.		
				Shore.	Brinell.					Shore.	Brinell.	
0	8·7	16·8	24·5	6·1	74		9·6	14·8	8·0	6·5	74·0	
1	7·5	16·3	31·5	5·5	71		9·2	15·3	14·0	6·5	92·0	
2	7·6	15·9	33·0	7·0	91		8·9	13·6	10·0	5·4	86·5	

The tensile bars, sand- and chill-cast respectively, are shown at Fig. 11.

The mechanical test results are plotted in Figs. 12 and 13. It will be seen that in sand-castings of this alloy increasing lead causes a slight falling away in the yield point and ultimate stress figures, with a corresponding increase in softness and ductility. The results from the chill-castings are, as usual, more erratic, but show on the whole the same tendencies.

As in the case of the 88 : 10 : 2 gun-metal, both sand- and chill-cast, the hardness figures of the sand-cast 85 : 5 : 10 alloy show a minimum, in this instance at a figure of 1 per cent. of lead, after which there is an increase in the hardness. The present alloy, however, when chill-cast, tends to show the reverse, a maximum hardness at the point in question.

No differences in soundness could be observed in the case of the three alloys in either method of casting.

The microstructure of the 85 : 5 : 10 alloy differs from that of Admiralty gun-metal in that the eutectoid has all disappeared, the alloy being now composed entirely of α. The lead, however, is still observable as separate segregations, or as cavities resulting from the tearing out of the same.

Taking the two investigations as a whole, one of the outstanding features is the fact that, up to a certain proportion, the addition of lead to zinc-tin-copper alloys considerably increases the ductility. This was referred to more than forty years ago by Boyd Dawkins,* who remarked, regarding the ancient bronzes, "Lead would increase the toughness of the alloy." The work now put on record affords an interesting confirmation of the correctness of this view, which would also appear to be in accordance with those of some of the other experimenters whose work has been referred to.

EXPLOSION OF A STEAM-HEATED CALENDER.

A REPORT on a Preliminary Inquiry under the Boiler Explosions Acts, 1882 and 1890, made by one of its Engineer-Surveyors, Mr. Binmore, Hull, has just been issued by the Board of Trade, with regard to the explosion of a steam-heated calender at the Cromwell Laundry, owned by the Cromwell Laundry Company, Peel-street, Hull. This occurred on February 28; one of the female workers being badly scalded and otherwise sustained severe injury.

The calender consisted of a hollow cast iron bed of semi-circular form, capable of being heated by steam admitted to the space between its inner and outer walls, and a cast iron roller, which revolved on a central shaft in the arc formed by the inner wall of the bed. The material to be ironed was passed through between the two and subjected to heat and pressure. The diameter of the roller was 18 in., and the arc of the inner wall of the bed was such that the roller was a working fit therein. The roller was not steam-heated. The bed was 6 ft. 8½ in. in length, and was of cast iron. The inner and outer walls generally ¾ in. thick, were connected one to the other longitudinally, the connections being at one side ½ in. thick, and on the other, which was at the side from which material was fed into the machine, ¾ in. thick. Six webs were cast at each end to form ties between the inner and outer walls, and also to provide anchorage for the screw bolts, eight in number and of ¾ in. diameter, which secured a cover plate at each end to close the openings between the webs. In addition, there were eight intermediate ties of 6½ in. by ¾ in. section. The surface of the inside wall and of the connection between the inner and outer wall at the delivery side of the bed were machined. There was also a groove, ⅛ in. wide by ¼ in. deep, machined longitudinally in the outer wall, into which a brass plate fitted in order to form a guide for the material leaving the machine.

The bed was heated by steam admitted through a ¾ in. bore iron pipe, and controlled by a screw-down stop valve of the same size. The outlet was by a similar pipe, connected with a steam trap of the thermo-regulated type. A steam pressure gauge registering to 160 lb. per square inch was fitted to a branch on the steam inlet pipe between the stop valve and the bed.

The machine was made by Messrs. Summerscales, Keighley, in 1906, and was therefore some 15 years old at the time of the explosion. The firm is now defunct. No repairs appear to have been made, except that the end covers were rejointed about August, 1920. The calender was not insured, and had not been inspected during its present ownership, but was inspected periodically from 1913 to 1919 whilst in the ownership of Mr. Davy, Snowflake Laundry, Hull, by the inspectors of the Vulcan Boiler and General Insurance Company.

When the explosion occurred the outer wall of the calender bed fractured longitudinally for almost its entire length, generally following the line of the groove which received the brass plate carrying the material from the machine. About two-thirds of the entire outer wall was forced downwards, and broke from the remainder of the casting into five sections. The framework carrying the bed of the machine was forced out of alignment, but no other damage was occasioned, except the case of personal injury above mentioned.

The explosion was caused by the bed, which had been previously partially fractured by stresses set up by unequal expansion, being unable to withstand the pressure to which it was subjected, there probably being present at the same time some stress due to unequal expansion through variation in temperature.

In his general remarks Mr. Binmore gives additional information, from which it would appear that the calender which exploded was used for the ironing of large pieces of linen, and was the smallest of three machines similar in general type. It was heated by the admission of steam from a boiler having a working pressure up to 120 lb. per square inch, and the only means of regulating the pressure in the bed of the calender was by a screw-down valve, which was opened

*"Early Man in Britain," 1st ed., 1880, page 409.

or closed by the girls operating the machine as they saw the pressure, as recorded on the gauge, falling or rising.

The machine was purchased second-hand from the proprietors of the Snowflake Laundry, Hull, and re-erected at the Cromwell Laundry in July, 1919, and is stated to have given no trouble prior to the explosion, except that the end covers required rejointing about August, 1920. No defect to the casting was then noticed by the fitter who did the work. Whilst this calender was in the ownership of the Snowflake Laundry it appears to have been worked with steam not exceeding 80 lb. per square inch, and on July 6, 1918, it was subjected to an hydraulic test by the Vulcan Insurance Company. The following appears in a copy of the inspector's report of this test :—

"I to-day witnessed test on this calender by hydraulic pressure to 120 lb. per square inch. The centre of bed and at about 12 in. from each end were gauged for deflection. The amount did not exceed $\frac{1}{32}$ in., which returned upon release of pressure, showing no permanent set; all parts were tight and dry, and test was satisfactory during period of 25 minutes."

Mr. Binmore adds that, from the fact that deflection is stated to have taken place, it is probable that the two ties showing evidence of fracture of long standing were in such condition when this test was applied.

The pressure on the boiler at the time of the explosion is stated by the attendant to have been 65 lb. per square inch. The calender bed had such abrupt changes in the thickness of its walls that, at the position of the machined groove running its entire length, severe stress must have occurred with changes of temperature, and the partial fractures present before the ultimate failure are accounted for thereby. The installation was such that, given a steam pressure of 120 lb. on the works boiler, a similar pressure could be obtained in the calender, the only safeguard being the vigilance of the girls working the machine. Since the explosion the safety valve of the works boiler, the report states, has been set to blow at 75 lb. per square inch, and in view of there being another machine of similar design to that which failed, working under such conditions that its steam pressure may be that of the boiler, the manager has been advised to have a reducing and safety valve fitted so that the pressure may not exceed 40 lb. The desirability of having the machine thoroughly inspected periodically has also been pointed out.

In his observations on the report, Mr. Thomas Carlton, the Engineer-Surveyor-in-Chief, says that "the calender had apparently in course of time been weakened by fractures which developed in the material, until it became unfit for the conditions under which it was used. The ribs, which were cast in the steam space to form ties between the inner and outer surfaces of the calender, were typical of a common and convenient method of stiffening hot plates and similar cast iron vessels subject to internal pressure. These internal ribs, however, Mr. Carlton adds, unless strongly made, are very liable to fracture, and the vessels in which they are cast should be carefully examined when possible, but in view of the general inaccessibility of the ribs, the vessels should also be tested periodically by hydraulic pressure. During the test the casting should be carefully examined for any deflections which might be indicative of broken ribs or weakness generally.

"The fittings on the calender were quite inadequate, and as no provision was made to prevent over-pressure, it is probable that the calender had been frequently subjected to higher pressures than should have been allowed in a vessel of this description. It is noted that it is proposed to reduce the boiler pressure from 120 lb. per square inch to 75 lb. per square inch, which will tend to safer working of the calenders remaining in the laundry, but while the boiler pressure continues substantially higher than the safe working pressure of the calenders, the installation cannot be regarded as satisfactory, unless each calender is provided with a relief valve set to the maximum safe working pressure for which the machine was constructed."

THE NEGATRON: A NEW NEGATIVE RESISTANCE DEVICE FOR USE IN WIRELESS TELEGRAPHY.*

By John Scott-Taggart.

Introduction.—The idea of a negative resistance is by no means a recent one. Looking back along the road of electrical progress the first important milestone of continuous wave wireless telegraphy is 1900, when Duddell first distinctly intimated how the arc produced oscillations. Since that date the arc has, for many purposes, become the chief means of communicating by wireless across long distances, and it is to Duddell's important appreciation of the value of negative resistance effects that we owe many of our modern achievements in radio communication.

For the benefit of those who are not *au fait* with a subject outside their usual field, we may briefly explain the value and meaning of negative resistance. We might define negative resistance as the exact opposite of ordinary or positive resistance. An electrical circuit ordinarily possesses resistance and resistance means wastage of power. A feature of an ordinary resistance is that if the voltage across it increases, the current through it increases. This seems quite what would be expected, but there are a few—a mere one or two—devices which obey an exactly opposite law. As the electromotive force across them increases, the current through them decreases and conversely. They obey the law $I = \frac{V}{-R}$. These negative resistance devices have always been of the very highest value in wireless reception and transmission. They have opened up new fields or provided alternative ones which have enabled wireless to develop untrammelled by monopolies. Some devices, although having negative resistance characteristics, have been useless in wireless telegraphy for the simple reason that they can only be employed in the case of circuits in which the current variations are of low frequency.

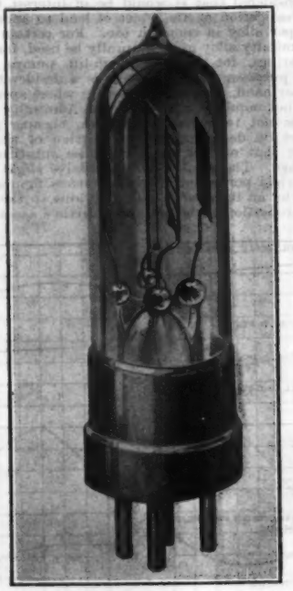


Fig. 1.

Fig. 2. CIRCUIT TO SHOW ACTION OF THE NEGATRON.

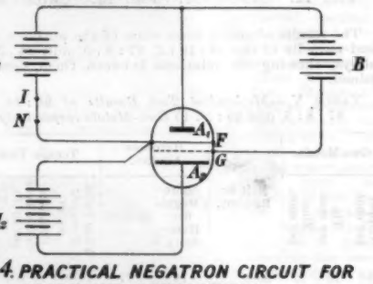
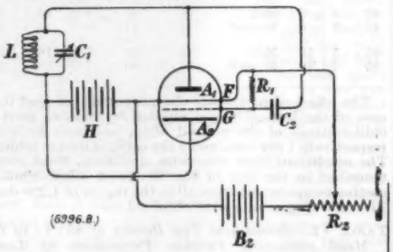


Fig. 4. PRACTICAL NEGATRON CIRCUIT FOR PRODUCING OSCILLATIONS.



Several negative resistance devices will work well, like Duddell's original arc, on low frequencies, but, as far as the author is aware, there are so far only two devices which have been shown to possess actual static negative resistance characteristics enabling high frequency oscillations to be produced. These are the arc and what has been called the Dynatron; of these, the arc undoubtedly prefers medium frequencies.

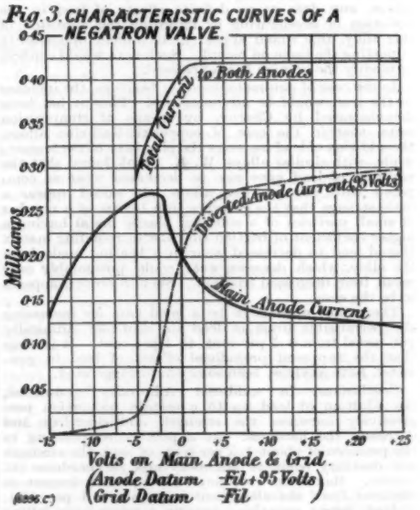
The chief value of a negative resistance is that if connected in series with a positive resistance circuit it will partially, or completely, neutralise the ordinary resistance of the circuit. This is a remarkable property, and enables signals of all kinds to be greatly amplified. For example, by the use of a negative resistance device, it is possible to cut down the resistance of long stretches of telegraph cable and save costs in this way. Wireless signals have also been amplified a thousand times by the use of a single negative resistance valve. The chief use of a negative resistance valve, however, is in the production of continuous oscillations for use in wireless transmission or reception by the beat method. Oscillations once set up in an oscillatory circuit will normally die out because of the resistance of the circuit which dissipates the energy. If, however, we can reduce the resistance of the oscillatory circuit to zero we enable the oscillations, once started, to persist. This is only a very rough method of explaining the production of continuous oscillations and waves, but it will no doubt suffice for the present occasion.

The Negatron.—The negatron valve was produced in September, 1919, and the author's patent for it (No. 166,260) has recently been accepted. The principle on which it works is briefly as follows: A thermionic valve is arranged having two flat anodes one on each side of a filament. Each anode is connected through an anode battery to the filament so that the electrons emitted by the filament, when it is heated to incandescence, are distributed fairly equally between the two anodes. A control electrode, which may be a flat grid, is also arranged within the valve between the filament and one of the anodes. This latter anode will be called the "diversion anode," while the first one will be called the "main anode." If we suitably arrange the relationship between the electron emission and the anode voltages, we may make the total of the anode currents approximately equal to the electron emission. In other words, a saturation effect is obtained. Under these conditions, if we make the grid more positive with respect to the filament we shall divert electrons from the main anode to the diversion anode, with a consequent reduction of the current flowing in the main anode circuit. In the negatron, as preferably used, the main anode is connected to the grid so that when the main anode voltage is increased the grid potential is increased, electrons are diverted from the main anode, and the main anode current decreases. Hence the negative resistance effect.

Theory of Action of the Negatron.—Fig. 1 illustrates the negatron valve itself. The anode on the left is the main anode (usually small), while the anode on the right is the diversion anode. Between the filament and the diversion anode is a flat openwork grid. A tubular valve with four-pin cap is preferred, the connection to the main anode being taken to the metal portion of the valve cap. A metal spring on the holdor presses against and makes electrical contact with this metal portion.

The action of the negatron will be best understood if reference is made to Fig. 2, which shows a negatron connected up in one way so as to possess negative resistance characteristics. Between the anode A_1 and the filament F is a battery H_1 and two terminals I, N. Between these terminals a milli-ammeter may, for the time being, be connected. The anode is connected through a battery B to the grid G. This battery is merely connected in this position to keep the grid at a suitable potential which is preferably slightly negative. If G were connected directly to A_1, G would have a high positive potential with respect to F. Between F and the diversion anode A_2 is a second battery H_2. Both H_1 and H_2 are usually of about 60 volts, but their values are not very important provided that the current supplied to the filament F may be adjusted to produce the saturation effect.

Fig. 3. CHARACTERISTIC CURVES OF A NEGATRON VALVE.



Let us now see what will happen if we increase the voltage of H_1. We should normally expect the current to A_1 to increase, but as the potential of A_1 increases so does that of the grid G. Since G becomes more positive, the current to A_2 will increase, and this increase could be measured by connecting a second milli-ammeter in the A_2 anode circuit. This method of varying (by altering the space charge) the current to A_2 is, of course, well known, as it has been used in ordinary valves since Lee de Forest first introduced the grid. The important fact to notice, however, is that, if the current to A_2 increases, the electrons which go to A_2 must come from those which would have gone to the anode A_1. There is, therefore, a diversion of electrons. If the A_2 anode current increases, the A_1 anode current must decrease, and conversely. Similarly a decrease of the A_1 anode current would always be accompanied by an increase of the A_2 anode current, and conversely

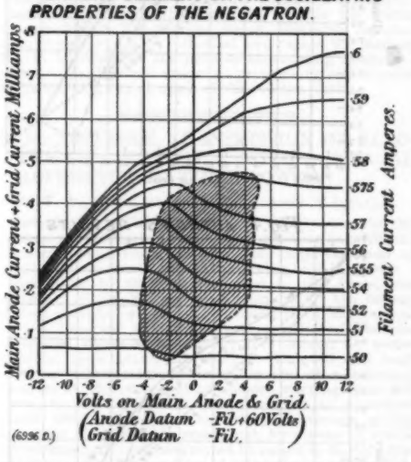
* Paper read before Section G of the British Association at Edinburgh, September 13, 1921.

This effect is conditional on the existence of saturation in the valve. Since by increasing the potential of the main anode A_1 we have diverted electron current to the anode A_2, the main anode current decreases. There are now two effects which govern the A_1 anode current. The increase in the A_1 anode potential tends to increase the A_2 anode current; the diversion effect, however, tends to decrease the A_1 anode current. The diversion effect greatly outweighs the other, and the result is a decrease in the main anode current consequent on an increase of the main anode potential; the converse also applies. A decrease of the main anode potential makes the grid G more negative and decreases the current to A_2. The A_1 anode current consequently increases. In this way, the negatron acts as a negative resistance.

The negatron, as described, works only when the saturation effect is obtained. For this reason, a filament current rheostat is desirable and the current through the filament is adjusted until the negative resistance effect is obtained. If the filament be too bright, there will be no "robbing" action. There will always be a plentiful supply of electrons around the filament and an increase of grid potential would increase the A_2 anode current and the additional electrons would come from the source round the filament and not from amongst those which would have gone to the main anode A_1. The A_1 anode current would therefore be unaffected and no negative resistance effect would be obtained.

Characteristic Curves of the Negatron.—The above explanation is borne out by characteristic curves obtained with the negatron, three of which curves are shown in Fig. 3. The thick line shows the main anode current. The top thin curve shows the sum of the two anode currents. The broken line represents the diversion anode current. Since the grid is always kept in the neighbourhood of zero volts, the grid current is almost zero. The grid is usually kept slightly negative, so that the grid current is zero. If this were not so, the grid current would add itself to the main anode current and the negative resistance slope would be less steep.

Fig. 6. DIAGRAM SHOWING EFFECT OF FILAMENT CURRENT ON THE OSCILLATING PROPERTIES OF THE NEGATRON.



The curves of Fig. 3 bring out very clearly the "robbing" action which the negatron utilises. The top curve shows that the negative resistance effect is obtained while the valve is saturated. Since the total current remains constant and the diversion anode current increases (due to the control electrode potential rising) the main anode current must of necessity decrease, and this is shown by the thick line curve which slopes downwards. The main anode current decreases to the left of the peak because the saturation effect is non-existent (as proved by the top curve) and the decreasing grid potential produces an increasing space charge between filament and main anode which decreases the main anode circuit. The curve is, of course, only used along its downward-sloping portion and oscillations will only be produced when the main anode and grid potentials are at suitable values. In practice, the grid potential is usually slightly negative and no grid voltage adjustment is necessary.

Applications of the Negatron.—To recount the applications of the negatron would take up too much space; they are as numerous and varied as those of the dynatron (which, of course, works on an essentially different principle). The main use of it is as a generator of continuous oscillations for the transmission or reception of continuous waves. It may be used for receiving spark signals by reducing the effect of positive resistance. As a local oscillator it is exceedingly convenient as it will oscillate on all ranges from 600 m. to 20,000 m. (the usual commercial range) without any complicated switching arrangements. The circuit arrangements which have been found most convenient are shown in Fig. 4. These are the same as those in Fig. 2, except that the two batteries are replaced by a single one H of about 60 volts. The main anode is connected through a leaky grid condenser C_2 to the grid G, a resistance R_1 being connected across grid and filament. This leaky grid condenser merely replaces the battery B of Fig. 2 for the purpose of avoiding a high positive grid potential. The filament F is heated by current from the 6-volt accumulator B_2 through the rheostat R_2, of about 7 ohms resistance. This rheostat is adjusted until continuous oscillations are produced in the oscillatory circuit LC_1. It is to be noted that the diversion anode circuit plays no other part in the circuit than as a path round which electrons are shunted. The A_2 anode current produces no effect whatever on the oscillatory circuit LC_1. If this anode were disconnected, the circuit would not, of course, oscillate even if there were plenty of electrons, because the phases of the grid potentials would be exactly opposite to those necessary to produce oscillations. As it is, the grid, over (and beyond) the working range, does not control the main anode current in any way, when the A_2 anode is disconnected.

Fig. 5 is a photograph of a commercial negatron oscillator designed for use as a local oscillator for beat reception. The circuit arrangements are similar to those of Fig. 4. A metal plate is preferably connected to a point along the inductance. This metal plate increases the strength of the oscillations induced in the receiver and it is preferably not connected at the end of L because this tends somewhat to damp out the oscillations on short wave-lengths. With regard to the design of this model, the author desires to acknowledge the work of Mr. Norman Lea, chiefly in designing the final dimensions of the valve electrodes to give the best results, and that of Messrs. Ree and Bainbridge-Bell in obtaining curves and designing the constants of the oscillatory circuit.

Before concluding, it will be of interest, no doubt, to demonstrate by means of curves the fact that the negatron only oscillates over a given range of filament current. Fig. 6 shows a series of characteristic curves. Main anode current curves are given for different values of filament current. The negative resistance effect disappears completely when the filament current is above 0·575 amperes. Likewise, it disappears, for another reason, when the filament current is very small. An oscillatory circuit will oscillate provided conditions are such as to come within the shaded area, and no difficulty is experienced in practice through the limited range of filament brightness.

FIG. 5.

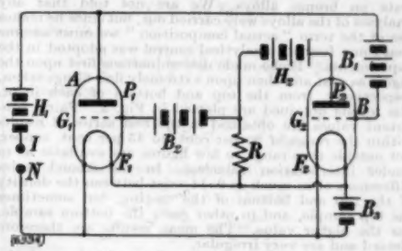
In conclusion, the author apologises for introducing still another item of valve nomenclature. A distinctive name, however, is particularly desirable for commercial reasons, and is also useful to designate briefly a novel scientific device.

A NEW DEVICE HAVING NEGATIVE-RESISTANCE CHARACTERISTICS.

By JOHN SCOTT-TAGGART.

ANOTHER addition to the formerly very small list of devices having negative-resistance characteristics is shown in the accompanying diagram. The arrangement employs two three-electrode valves, one acting as a conductor of current and the other as a phase-reverser. The valve A is the conductor of current from the battery H_1. Let us imagine an ammeter included across the terminals I, N. If the E.M.F. of H_1 were increased we should expect the anode current to be increased. The opposite effect is obtained, however, by arranging that the increase in the anode voltage of P_1 increases the potential of the grid G_2 of the valve B. The normal potential of G_2 is kept near zero by a battery B_1. In the anode circuit of B_1 is an anode battery H_2 and a resistance R. When G_2 becomes positive, the anode current through R increases, making the grid G_1 of the valve A more negative. The battery B_2 keeps the grid G_1 at a suitable normal potential near zero. By increasing H_1 we therefore have two effects: One is a tendency to produce an increase of anode current by increasing the anode potential; the other is a tendency to decrease the anode current by making the grid more negative. This latter effect greatly outweighs the former, so that the anode current decreases and a negative-resistance characteristic is obtained. If the voltage of H_1 be decreased the converse effect takes place. The circuit, the resistance of which is to be decreased, is

THE "BIOTRON" NEGATIVE RESISTANCE DEVICE.



normally connected across I, N. This static negative-resistance device can produce a very steep negative characteristic. The curve, moreover, is straight. This particular negative resistance bears, at first glance, a certain resemblance to other resistance coupled arrangements, but as far as operation is concerned this is not the case.

The arrangement shown in the diagram is perfectly stable. There is no building-up or retro-active action, as in the devices using two anode resistances. In the diagram the negative-resistance current does not itself produce any further change in any of the grid potentials. This is not the case with the arrangements the author is thinking of wherein the negative-resistance current passes through a resistance and produces a building-up action. The arrangement is described more fully in the author's British patent 152,693 (July 25, 1919). The diagram has been reproduced by permission of the Wireless Press, Limited, from the author's book "Thermionic Tubes in Radio-Telegraphy and Telephony."

THE DENSITY OF THE COPPER-ZINC ALLOYS.*

By T. G. BAMFORD, M.Sc., Member (Birmingham).

THE "density" or "mass per unit volume" has for long been accepted as one of the physical constants and, as such, its values have been obtained for a very large number of elements, compounds, and mechanical mixtures.

Investigators have, however, largely confined their attentions to determinations of the densities of fluids, and this is owing to the fact that the various physical constants of a fluid are functions of the state of the fluid at the moment, while in solids that is not in general the case. Ordinary solids such as the metals and alloys will show varying specific properties, but the values of such properties will be governed entirely by composition, condition, and previous history. A sample of 70 : 30 brass, for example, will have a density that is dependent upon the casting conditions, precise composition, mechanical and thermal treatment to which it has been subjected, and upon the prevailing environmental conditions.

The determination of the density of metals and alloys may be carried out rapidly, and with a fair degree of accuracy, in the laboratory, and could therefore more generally be used as an aid to deciding whether they have received satisfactory treatment at each stage of manufacture.

After casting a brass billet an analysis will decide whether the required composition has been attained, and a density determination should indicate whether correct casting conditions have been observed and, in fact, whether a sound casting has been obtained. Unfortunately, no accepted standard figures are available to which the densities of particular alloys cast under specified conditions should conform. It is hoped that the present paper will supply this practical demand for information in the case of the copper-zinc series.

Earlier Work.—In 1842 R. Mallet published data respecting the alloys of copper and zinc, in which was included a table of specific gravities of 21 alloys of different compositions. No information, however, is available regarding methods adopted in casting these alloys, and the results obtained are so irregular as to be almost worthless. Whereas some regularity is observable at the copper-rich end of the series, the results are entirely erratic for all alloys containing more than of 50 per cent. zinc, the gravities rising and falling sharply six times in passing from the range of composition of 50 per cent. zinc to that of 25 per cent. zinc.

In 1859 F. Crace Calvert and R. Johnson published a paper upon the properties of certain alloys, and submitted density values for nine different copper-zinc

* Paper read before Section G of the British Association at Edinburgh, September 13, 1921.

* Abstract of a paper read at the Birmingham meeting of the Institute of Metals, September 21, 1921.

alloys. They give no details at all concerning methods of casting. Their results are plotted in Fig. 1, and it has been possible to construct a smooth curve which would pass close to seven of the nine points. For comparative purposes in this case and in all cases hereafter mentioned, the theoretical density curve (assuming there to be no expansion or contraction due to the alloying) has been plotted alongside the actual curves obtained by the various experimenters.

In 1873 A. Riche also cast a number of these alloys, and he is the first research worker who records any information as to experimental methods; 60 to 100 grm. ingots of each alloy were cast in the same mould. While no definite statement is made, a reader of Riche's paper would tacitly infer that he used a cylindrical iron mould, as he states precisely that he did so in certain tests on bronze alloys. We are not told that any analyses of the alloys were carried out, but since he makes use of the term "actual composition" we must assume that some form of analytical control was adopted in the experiments. Riche made determinations first upon the ingots as cast and then upon extremely fine filings taken, respectively, from the top and bottom of each ingot. His results obtained are plotted in Fig. 2. Fairly consistent values are obtained in the first series of results within the range of 90 per cent. to 35 per cent. copper, but outside that range so few figures are available as to render interpolation valueless. In the second series differences of as much as 0·14 exist between the density of the top and bottom of the casting, but sometimes the top sample, and in other cases the bottom sample, has the higher value. The mean results are therefore plotted and are very irregular.

In 1901 E. Macy made new determinations of the density of the copper-zinc alloys, particularly with the hope of establishing the existence of chemical compounds between the elements copper and zinc. He melted small 10-grm. samples of pure copper and zinc, in small covered porcelain crucibles, and allowed the alloy to solidify in the crucible. Allowance for loss of zinc by volatilization was made when weighing out the sample, but no analysis was made of each alloy as a check upon its composition. The samples were subjected to prolonged boiling in water prior to each density determination, in order to avoid the existence of air spaces, which according to Macy may be completely filled with water by this treatment. He concludes that the detection of chemical compounds is masked by the presence of solid solutions and cannot, therefore, be made by density or specific volume determinations but must be done by other methods.

Very recently Rudolf H. Weber, in investigating the magnetic susceptibility of the copper-zinc alloys, had occasion to obtain their specific gravities. He made two series of determinations. In the first, zinc was heated to the melting point, and small portions of pure copper, mixed with ammonium chloride, were added thereto. The temperature was maintained not higher than the melting point of each alloy. In the second series, copper was melted under borax and the zinc added. The temperature was raised considerably above the melting point.

In all cases small Berlin porcelain crucibles were used, and the mould consisted of sand bound together with china clay. No attempt was made to ensure the obtaining of sound castings, as Weber specifically states that casting faults do not influence his magnetic measurements. His second series of results are plotted in Fig. 3.

Only two investigators, Riche and Weber, have analysed the alloys used in the density determinations. All made very small castings; none records agreement of duplicate determinations on different samples cut from the same casting; and none, apparently, adopted any special precautions to ensure that the samples were sound.

It is true that Riche made determinations, using powder filed from the top and bottom of each sample, but his results are not concordant. It is also true that Macy endeavoured to avoid the effects of porosity by boiling his samples in water; but this, if successful, would at once render the results useless to the practical man who wants to know what density an ordinary sound specimen of given composition should have, if cast successfully under given conditions. He further wishes to know if, for example, a chilled specimen should have a different density from one cooled slowly, and what should be the values in each case.

Mr. J. H. Teng, working in Professor Turner's laboratory at Birmingham University, during the years 1917–18, upon the alloys of zinc and aluminium, found that both sand and chill castings had density values throughout which were lower than postulated by theory if no volume changes occurred when the two metals were alloyed. He found, however, that in all cases the chill-cast specimens had higher values than the sand-cast specimens.

In no published data is there any attempt to differentiate between the density of chilled and of sand-cast specimens. Weber is the only research worker on the copper-zinc series who tells us that he used a sand-mould, and Riche leads us to believe that chill-moulds were adopted.

Method of Procedure.—In the present investigation both chill and sand cast billets of a cylindrical shape, 12 in. long and 1 in. diameter, were poured from each heat and comparative values of the density obtained. The weights of the billets varied from 2 lb. 8 oz. to 3 lb. 1 oz., according to composition.

The chill-mould was of the ordinary split cannon type made in cast iron. The sand-mould was made up in ordinary caster's loam.

Cathode plate copper and M.M.C. zinc were used.

The heats were melted in open Salamander pots in coke fires under borax. It was not possible to record the temperatures, but in all cases a pouring temperature was used which would result in a sound casting. After casting, the outside skin of each billet was turned down in a lathe for a distance of about an eighth of an inch. If the metal did not appear to be perfectly sound, the experiment was discontinued and fresh castings were made until sound ingots were obtained. The turnings were used for analysis. The composition of the billets was found to be uniform throughout.

If either chill or sand casting were unsound the two samples were rejected, but it should be mentioned that the sand-casting was usually the more difficult to obtain quite sound.

Cylindrical samples weighing 30 to 60 grms. were prepared for the density determinations by turning down in the lathe, cutting off about 10 c. from the bottom of the casting, and polishing with smooth file and French emery-papers. The samples were weighed in air and in redistilled and boiled water. Suspension of the samples from the balance was effected by means of a small platinum stirrup. The stirrup itself was always submerged in water to a fixed mark when determining the weight of a sample in water.

The volume of the stirrup up to this mark was determined by weighing it in air and in water. An error would be introduced due to surface tension, but the same error would occur not only in weighing in air but also in taking the weights of all the samples in water; it will readily be understood, therefore, that surface tension effect would not influence the density results. No allowance was made for the density of the air, as the influence of this factor would be less than the limit of accuracy permitted by other factors. The temperature of the water at the time of each observation was, of course, noted and taken into consideration in all calculations. The densities were taken at 18 deg. C., referred to water at 4 deg. C. as 1·000.

The degree of accuracy was such that separate determinations upon the same sample, at different times, would agree to less than 0·005 absolute value. Agreement between separate samples cut from the same bar could be obtained to less than 0·02 absolute value. It might be argued that this was not a high degree of accuracy, but it was found that a sound sample differed from an unsound specimen by as much as 0·38.

The results obtained are plotted in Fig. 4, on which curve the results obtained with sand and with chilled castings are both shown.

Those points obtained by Crace Calvert, which are consistent amongst themselves, also agree very closely with the results of the chill-cast determinations made by the author.

Riche's results, obtained upon the ingots, agree within the range of composition of 90 per cent. to 35 per cent. copper remarkably well with the author's chill-cast results. Below 35 per cent. copper Riche's results, as previously stated, are insufficient, but indicate a rapid fall in density value in this range.

With Macy, the author confesses that he can discern agreement only within a very small range of composition, and it can only be suggested that this is due to the fact that no analysis was carried out and also to Macy's *modus operandi*, in which he boils his specimens in water prior to each density determination.

With Weber's results, as might be anticipated, no very close concordance is obtained.

Referring now to the author's results in detail, it is to be noted that with one exception, namely, 60·7 per cent. copper, the densities of the sand-cast specimens are less than those of chill-cast ones, and that in this exceptional case the two densities differ by less than the limit of experimental error.

The two curves run side by side with points of very close proximity at 40 per cent. copper and 24 per cent. copper. They have maximum divergence at about 83 per cent. copper, 50 per cent. copper, and 35 per cent. copper.

In the entire region extending from pure copper down to 30 per cent. zinc, a net contraction has taken place due to alloying and solidification of the two metals. This is revealed by both curves, except for a small part of the sand-cast curve, as they are above the theoretical density curve. Below 30 per cent. zinc, however, a very marked expansion takes place, culminating in minimum density values at 12 per cent. copper.

The results fall into line with Shepherd's curve for the copper-zinc series, and also afford remarkable confirmation of the data published by Turner and Murray (see ENGINEERING, vol. lxxxviii, page 586) on the volume changes of the copper-zinc alloys, establishing the fact that the changes recorded therein were actual volume changes and were not caused merely by thrust or by longitudinal movement, as had been suggested might be the case.

The points at 61 per cent. copper and 40 per cent. copper correspond very closely with the points A and B on Shepherd's diagram, and also with the points at which Turner and Murray record a zero expansion upon solidification.

Points of maximum divergence between the curves for chill and sand castings, which occur at 83 per cent. and 50 per cent. copper, correspond to points of maximum divergence between liquidus and solidus on Shepherd's curve and to points of maximum recorded by Turner and Murray.

When the liquidus and solidus curves come together as they do at the points A and B on Shepherd's curve, the alloy would have a uniform composition whether slowly cooled or chilled. When, on the other hand, we are dealing with an alloy corresponding to a composition at which liquidus and solidus are widely different,

Fig. 1. CALVERT AND JOHNSON'S RESULTS

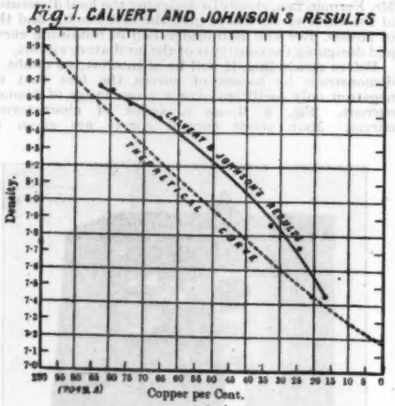


Fig. 2. RICHE'S RESULTS

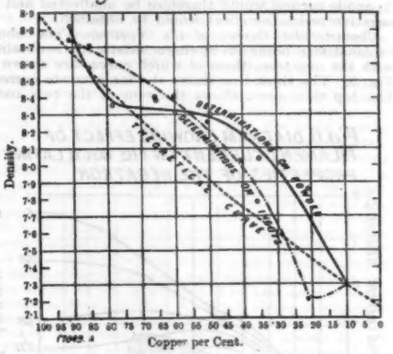


Fig. 3. WEBER'S RESULTS-SECOND SERIES

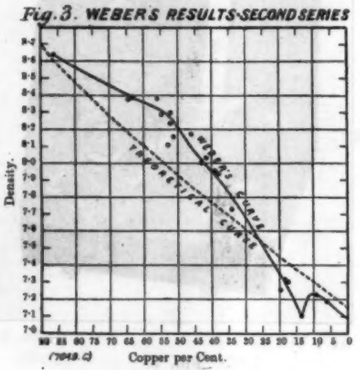
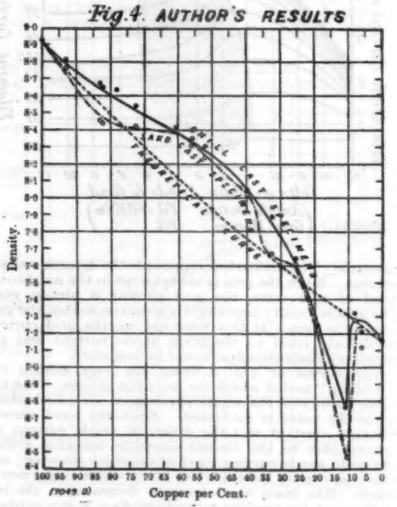


Fig. 4. AUTHOR'S RESULTS



quick chilling from the molten state may produce a cored, heterogeneous structure, as is in fact well known to be the case with chill-cast brasses having a copper content above 65 per cent. copper. In such a case the last crystals to form may constitute a phase which would not have formed at all under conditions of slow cooling.

It is to be anticipated, therefore, that, while alloys corresponding to the points A and B would have equal density values whether chill- or sand-cast, alloys having other compositions would have different metallographical structure, and therefore different density values according to their rate of cooling after having been poured into the mould. The agreement between these theoretical considerations and the actual results indicates, the authors believe, a confirmation of the accuracy of the results.

The equilibrium diagram of alloys whose compositions contain less than 30 per cent. copper is so complicated that it is difficult to draw parallels between the density curves and the equilibrium diagram. Some new factor appears which causes a remarkable expansion and affords striking confirmation of the expansion recorded by Turner and Murray. Samples in this region have been prepared which turn easily in the lathe and appear perfectly sound, but which may be caused to absorb large quantities of water by prolonged immersion therein. We are evidently dealing here with a new form of porosity different from ordinary unsoundness.

The work recorded in this paper was initiated by Professor Turner in his laboratory at the University of Birmingham, and the author wishes to express his indebtedness to him for his interest, advice, and aid in the prosecution of the work.

The author wishes also to express his gratitude to Mr. W. E. Ballard, who helped him with some of the early casting work.

It is also the author's pleasure to record his appreciation of the sympathy extended towards his works by the British Non-Ferrous Metals Research Association, which extended practical sympathy by loaning Mr. B. Bloomer for the purpose of assisting in the research. Mr. Bloomer was most painstaking and reliable in his carrying out of much of the routine work.

LONG DISTANCE TRANSMISSION OF ELECTRICAL ENERGY WITH SPECIAL REFERENCE TO TIDAL POWER.*

By T. F. WALL, D.Sc., D.Eng., Assoc.M.Inst.C.E.

Introductory.—The utilisation of tidal power for the generation of electricity involves a peculiar and difficult problem arising from the extremely large variation of speed of the turbines under the varying head of water.

According to the reports issued in the Press, the proposals of the Ministry of Transport for the Severn scheme provide for an average generation of 500,000-h.p. over a 10-hours' day. The scheme involves the use of special direct-current generators driven by water turbines, these generators being so designed that each machine will develop about 1,300 kw. at a constant pressure of 525 volts and at a speed varying from 300 r.p.m. to 500 r.p.m. The direct-current so generated would then be supplied to rotary converters giving 320 volts alternating current, and, by means of static transformers, this pressure would be raised to 60,000 volts which would be the pressure of transmission to the Midlands. Transmission to London—a distance of 115 miles—is suggested at a pressure of 120,000 volts.

Owing to the varying speed of the turbines, the use of alternating-current generators driven by the turbines is, in the ordinary way, not practicable, since the generated e.m.f. would be of varying frequency; for the speed range given above, the maximum value of the frequency would be 1·66 times the minimum value. Moreover, unless elaborate automatic arrangements were made, the generated e.m.f. would also vary in magnitude more or less in proportion to the speed variation.

Such large variations of frequency and e.m.f. would be impracticable for feeding a distribution system, for the obvious reasons that motors, such as induction motors or synchronous motors, would have similar speed variations independently of the requirements of the consumer, and lighting and heating appliances cannot be operated from a system of which the pressure is widely varying.

It is clear that the proposal to generate 500,000-h.p. by means of 1,300 kw. direct-current units, and then to convert to alternating current by means of rotary converters, would involve an immense number of machines. The duplication of machines necessary owing to the generation, in the first instance, as direct current, and then conversion to alternating current, is a very serious matter, and the capital outlay for these machines alone would probably be sufficiently large to imperil the feasibility of the scheme. From criticisms and discussions of the proposals which have appeared from time to time, it is clear that the immense capital outlay involved in realising the installation would very likely be fatal to the success of this otherwise most attractive project.

The successful exploitation of tidal power will depend on the solution of the peculiar electrical engineering difficulties inherent in such an undertaking, and electrical engineers should be prepared to strike out on new lines as may be necessary to meet these requirements.

The purpose of the present paper is to give very briefly, a preliminary outline of an alternative system obviating the difficulty of the varying speeds of the turbines. The system permits of the use of alternating-current generators driven directly from the turbines, and it is expected that an appreciable saving in capital outlay will result. The system also presents other advantageous features.

Briefly stated, the scheme involves the generation of alternating current at such a frequency that the length of the transmission line at one turbine speed (viz., the lowest) will be equal to or approximately equal to one quarter the wave length of the travelling waves of p.d. and current which will be established in the line. As the speed of the turbines increases, the frequency of the generated alternating current will increase correspondingly, and, if the excitation is constant, the generated e.m.f. will also increase correspondingly. As the frequency increases, the wave length decreases so that, if at the lowest speed the length of the line is one-quarter wave length, then at double this speed the length of the line will be one-half wave length.

Assuming constant current at the receiving end of the line, it is shown that, notwithstanding the rise of the generator voltage as the speed rises, the voltage at the receiver's end of the line will remain constant.

The arrangement thus results in an alternating-current supply at the receiver's end of the line of constant voltage and variable frequency.

So long as the p.d. is constant and the frequency is high, a variable frequency is not objectionable for heating and lighting apparatus. In order to obtain a supply suitable for driving motors, &c., it is proposed to convert, by means of mercury-arc rectifiers, to direct current, and it is shown that, by such means, a constant alternating-current voltage of variable frequency generated and transmitted in the manner already described, may be transformed to a direct-current supply of constant current and very approximately constant voltage.

Generation and Transmission.—The following equations express the relationships between the line constants and the voltage and current vectors at the receiving end and the generator end of the line, respectively, viz.:

$$\dot{V}_1 = \tfrac{1}{2}\left[\left(\dot{V}_2 + \dot{I}_2 Z_0\right)e^{\alpha l}\right]e^{j\beta l} + \tfrac{1}{2}\left[\left(\dot{V}_2 - \dot{I}_2 Z_0\right)e^{-\alpha l}\right]e^{-j\beta l}$$

$$\dot{I}_1 = \tfrac{1}{2}\left[\left(\dot{I}_2 + \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{\alpha l}\right]e^{j\beta l} + \tfrac{1}{2}\left[\left(\dot{I}_2 - \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{-\alpha l}\right]e^{-j\beta l}$$

where $\dot{V}_1$ represents the vector of p.d. at the generator end,

$\dot{I}_1$ represents the vector of current at the generator end,

$\dot{V}_2$ represents the vector of p.d. at the receiving end,

$\dot{I}_2$ represents the vector of current at the receiving end,

l represents the length of the transmission line,

α represents the attenuation constant,

β represents the wave length constant,

e is the base of natural logarithms, viz., $e = 2{\cdot}718$,

and $j = \sqrt{-1}$.

Further,

$$\alpha^2 = \tfrac{1}{2}\left[\sqrt{(g^2 + b^2)\,(R^2 + X^2)} + (g\,R - b\,X)\right],$$

$$\beta^2 = \tfrac{1}{2}\left[\sqrt{(g^2 + b^2)\,(R^2 + X^2)} - (g\,R - b\,X)\right],$$

in which g is the insulation resistance per unit length of the line,

b is the capacity susceptance per unit length of the line,

R is the resistance of the line per unit length,

X is the reactance of the line per unit length.

Also,

$$b = \omega C = 2\pi f C,$$

$$X = \omega L = 2\pi f L$$

in which C farads is the line capacity per unit length,

L henrys is the line inductance per unit length,

f is the frequency.

The vector $Y = g + jb$ is the vector of admittance per unit length of line, and the vector $Z = R + jX$ is the vector of impedance per unit length of line.

For the high frequency necessary for this proposed system, R is negligibly small, and for well-insulated overhead transmission lines working at a pressure below that corresponding to "corona" effects, the value of g will also be negligibly small.

When $g = 0$, and $R = 0$, the value of the attenuation constant α will also be zero, and the wave length constant will be

$$\beta = \sqrt{bX} = 2\pi f\sqrt{LC}.$$

The wave length of the travelling waves of p.d. and current along the line is given by

$$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{2\pi f\sqrt{LC}}$$

Further, the vector $\dot{Z}_0$ is defined by

$$\dot{Z}_0 = \sqrt{\frac{\dot{Z}}{\dot{Y}}} = \sqrt{\frac{X}{b}}$$

and is termed the "initial sending end impedance."

Since $\alpha = 0$, $e^{\alpha l} = 1$, and the equations expressing the relationships between the vectors of p.d. and current at the generator end and the receiver's end, respectively, may be written

$$\dot{V}_1 = \tfrac{1}{2}\left(\dot{V}_2 + \dot{I}_2 Z_0\right)e^{j\beta l} + \tfrac{1}{2}\left(\dot{V}_2 - \dot{I}_2 Z_0\right)e^{-j\beta l}$$

$$\dot{I}_1 = \tfrac{1}{2}\left(\dot{I}_2 + \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{j\beta l} + \tfrac{1}{2}\left(\dot{I}_2 - \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{-j\beta l}$$

For one-quarter wave length conditions

$$l = \tfrac{1}{4}\lambda = \tfrac{1}{4}\left(\frac{2\pi}{\beta}\right),$$

$$\beta l = \pi/2,$$

$$\dot{V}_1 = \left(\dot{I}_2 Z_0\right)e^{j\pi/2}$$

that is

$$\dot{V}_1 = j\left(\dot{I}_2 Z_0\right) = j\sqrt{\frac{X}{b}}\,\dot{I}_2$$

Similarly,

$$\dot{I}_1 = j\left(\frac{\dot{V}_2}{\dot{Z}_0}\right) = j\,\dot{V}_2\sqrt{\frac{X}{b}}$$

For one-half wave length conditions,

$$l = \tfrac{1}{2}\lambda : \beta l = \pi$$

$$\dot{V}_1 = \dot{V}_2 e^{j\pi}$$

that is,

$$\dot{V}_1 = -\dot{V}_2$$

Similarly,

$$\dot{I}_1 = -\dot{I}_2$$

For three-eighth wave length conditions,

$$l = \tfrac{3}{8}\lambda : \beta l = \frac{3\pi}{4},$$

$$\dot{V}_1 = \tfrac{1}{2}\left(\dot{V}_2 + \dot{I}_2 Z_0\right)e^{j\frac{3\pi}{4}} + \tfrac{1}{2}\left(\dot{V}_2 - \dot{I}_2 Z_0\right)e^{-j\frac{3\pi}{4}}$$

$$\dot{I}_1 = \tfrac{1}{2}\left(\dot{I}_2 + \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{j\frac{3\pi}{4}} + \tfrac{1}{2}\left(\dot{I}_2 - \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{-j\frac{3\pi}{4}}$$

Example.—As an example, consider the following case, viz.: A three-phase transmission of which the lines are symmetrically arranged, and having a spacing of 10 ft. between any two lines. The conductors are of 0·42-in. diameter. The pressure at the receiving end of the line is 90,000 volts between the lines and the power supplied to the receiver is 15,000 kw. at unity power factor. The line is 115 miles long.

From these data the following results may be deduced. The equivalent star capacity of the three-phase line is 0·014 micro-farad per phase per mile; the inductance is 0·0021 henry per phase per mile; the phase pressure at the receiving end is 52,000 volts; the line current at the receiving end is 96 amperes.

The wave-length constant is

$$\beta = 2\pi f\sqrt{LC} = 2\pi f\left(\frac{5{\cdot}45}{10^6}\right)$$

The wave length is

$$\lambda = \frac{2\pi}{\beta} = \frac{1}{f\sqrt{LC}} = \frac{10^6}{5{\cdot}45\,f}\ \text{miles.}$$

The frequency f at which the length of the line will be one-quarter wave length is given by

$$115\ \text{miles} = \tfrac{1}{4}\lambda = \frac{1}{4}\left(\frac{10^6}{5{\cdot}45\,f}\right)$$

that is, the frequency is 400 cycles per second, and $\beta l = \frac{\pi}{2}$.

Similarly, for three-eighth wave length the frequency is 600 cycles and $\beta l = \frac{3\pi}{4}$.

For one-half wave length, the frequency is 800 cycles per second and $\beta l = \pi$.

The pressure per phase at the receiver end of the line is 52,000 volts.

The current per line at the receiver end of the line is 96 amperes.

The value of Z_0 is $\sqrt{\frac{X}{b}}$, that is, $Z_0 = 388$.

Hence the following results are obtained, viz.:—

For a frequency $f = 400$ cycles per second, that is $\beta l = \frac{\pi}{2}$

$$\dot{V}_1 = j\left(\dot{I}_2 Z_0\right) = j\,(37{,}200)\ \text{volts},$$

$$\dot{I}_1 = j\left(\frac{\dot{V}_2}{\dot{Z}_0}\right) = j\,(132)\ \text{amperes.}$$

The magnitude of $\dot{V}_1$ in this case is thus 37,200 volts, and the magnitude of $\dot{I}_1$ is 132 amperes.

For a frequency of $f = 600$ cycles per second, $\beta l = \frac{3}{4}\pi$. Assuming that $\cos\phi_2 = 1$, that is the vectors $\dot{V}_2$ and $\dot{I}_2$ are in phase, then

$$\dot{V}_1 = \tfrac{1}{2}\left(\dot{V}_2 + \dot{I}_2 Z_0\right)e^{j\frac{3\pi}{4}} + \tfrac{1}{2}\left(\dot{V}_2 - \dot{I}_2 Z_0\right)e^{-j\frac{3\pi}{4}}$$

that is,

* Paper read before Section G of the British Association at Edinburgh, September 13, 1921.

$$\dot{V}_1 = (45{,}500)\, e^{j2\cdot52}$$

and

$$\dot{I}_1 = \tfrac{1}{2}\left(\dot{I}_2 + \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{j\frac{3\pi}{4}} + \tfrac{1}{2}\left(\dot{I}_2 - \frac{\dot{V}_2}{\dot{Z}_0}\right)e^{-j\frac{3\pi}{4}}$$

that is

$$\dot{I}_1 = (116)\, e^{j2\cdot10}$$

The magnitude of $\dot{V}_1$ in this case is 45,500 volts, and the magnitude of $\dot{I}_1$ is 116 amperes.

For a frequency $f = 800$ *cycles per second,* $\beta l = \pi$. and

$$\dot{V}_1 = -\dot{V}_2$$
$$\dot{I}_1 = -\dot{I}_2$$

Hence the magnitude of $\dot{V}_1$ in this case is 52,000 volts and the magnitude of $\dot{I}_1$ is 96 amperes.

It thus appears that the magnitudes of the voltage and the current at the receiver end of the line will remain constant if the voltage at the generator end of the line is increased with the frequency as follows :—

Frequency.	Voltage at the generator end of the Line.
400	37,200
600	45,500
800	52,000

If the excitation of the generators is maintained constant, the induced e.m.f. of the generators will rise at a higher rate than that shown in the above table, and, consequently, allowing for pressure drop in transformers and machines, it will be possible to obtain an available pressure rise at the generator end of the line which will be of the amount necessary to maintain the voltage at the receiver end constant. If so desired, the voltage at the receiver end may be allowed to rise by a definite percentage with the frequency.

As regards the assumption that cos ϕ_2 is unity when the frequency is 600 cycles per second, it may be noticed that, for the proposed system of mercury-arc rectification, the power factor of the arc would normally be about 0·8 In order to obtain unity power factor, static condensers may be used, and on account of the high frequency employed in the system, the amount of such capacity necessary would be quite small. For example, if the low-tension side of the transformers at the receiving end of the line is operated at 2,000 volts and the power is 5,000 kw. per phase, the power factor being raised from 0·8 to unity by means of condensers connected in parallel with the load, it follows that the condensers must take a current of about 1,870 amperes per phase. At 2,000 volts and for a frequency of 600 cycles per second, the amount of capacity necessary will accordingly be 250 micro-farads per phase.

Calculations similar to those already given show that if the power factor cos ϕ_2 at the receiving end of the line is leading, the effect described in the foregoing may be obtained with smaller values of the frequencies. Thus, for cos $\phi_2 = 0\cdot8$ leading, the lower limit of the frequency range may be about 200 cycles per second.

These results are summarised in the curves shown in Figs. 1, 2 and 3, which show the phase p.d. which is necessary at the generator end of the line in order that the phase p.d. at the receiver end of the line shall remain constant with varying generator frequency. In each case it is assumed that the load at the receiver's end of the line is constant and equal to 15,000 kilowatts.

Fig. 1 shows the conditions for unity power factor at the receiver's end of the line, that is, cos $\phi_2 = 1$: line current = 96 amperes.

Fig. 2 shows the conditions for cos $\phi_2 = 0\cdot8$ leading : line current = 120 amperes.

Fig. 3 shows the conditions for cos $\phi_2 = 0\cdot8$ lagging : line current = 120 amperes.

Mercury-Arc Rectification at the Receiver's End of the Line.—The use of mercury-arc rectifiers for large powers has in recent years become of great practical importance, and considerable experience in the manufacture and use of large power units is now available.

The theory of this apparatus has been worked out in great detail by Dr. C. P. Steinmetz.

Assuming that the rectified load per phase is 5,000 kw., viz., 2,500 amperes at 2,000 volts, and assuming values for the reactance and resistance of the rectifier circuit and load, the following values have been calculated for the p.d., which is necessary at the secondary terminal of the transformer to which the rectifier is connected. The calculations are based on the assumption that the direct-current voltage and current are kept constant at the values given above.

Frequency of the Alternating Current supplied to the Rectifier.	P.D. at the Secondary Terminal of the Transformer to which the Rectifier is Connected.
Cycles per Second.	Volts.
400	5,500
600	5,650
800	5,900

It thus appears that for 100 per cent. variation in the frequency, viz., from 400 cycles to 800 cycles per second, it is only necessary that the p.d. should vary by 7 per cent. in order that the rectified current and pressure should remain constant.

A considerable number of alternating-current machines for frequencies up to 600 cycles per second have been built within the last few years for special purposes, so that there is a good deal of information available with respect to the design and performance of these machines.

As already stated, for lighting and heating purposes it would not be necessary to rectify the variable frequency alternating current. If the voltage drop with increase of frequency were troublesome in the distribution system, this could be compensated for by allowing the voltage at the receiver's end of the line to rise by a definite percentage as the frequency increases, instead of maintaining this voltage constant.

Apart, therefore, from lighting and heating load requirements, the main distribution supply system would be direct current, according to the present proposals. For many requirements, a direct-current supply

Fig. 1.

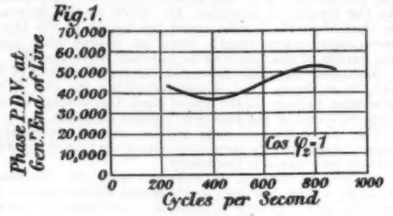


Fig. 2.

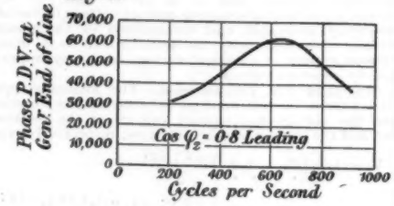
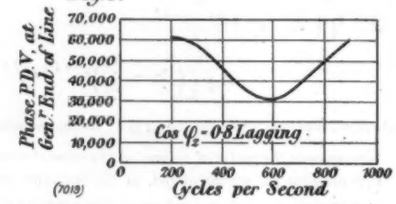


Fig. 3.



(7019)

would be necessary even if the alternating-current transmission were at constant frequency. For a large number of other purposes a direct-current supply offers advantages over an alternating-current supply.

It will be observed that the present proposals involve the existence of a consumers' load of constant magnitude. If a large industrial area is supplied, such constancy of load is not difficult to obtain, and by the establishment of electro-chemical and metallurgical industries in or near the areas supplied, a practically constant load could be ensured. The extremely good load factor so obtained would ensure practically ideal conditions as regards minimum cost of supply.

CATALOGUES.

Roller Bearings.—Messrs. Hyatt, Limited, 4, Thurloe-place, London, S.W. 7, have issued a special catalogue dealing with the application of their flexible roller bearings to trucks, trams and colliery tubs.

Machine Tools, &c.—A catalogue of lathes, drilling, grinding and other machines, as well as small tools and workshop accessories, has been received from Messrs. Morton and Weaver, Cox-street, Coventry.

Bitumen.—Preparations of bitumen for protecting and preserving electric cables are described, and their application illustrated in a little booklet issued by the Dussek Bitumen Company, Empress Wharf, Bromley-by-Bow, London, E. 3.

Electric Light Fittings.—A large selection of reflectors, lanterns, brackets and all fittings necessary for indoor and outdoor electric lighting is illustrated and fully described in an excellent catalogue which we have received from the Edison Swan Electric Company, Limited, Ponders End, Middlesex.

Turbine-Driven Pumps.—A mass of information relating to centrifugal pumps driven by steam turbines in water works service is presented in a handsome book of 100 quarto pages received from the De Laval Steam Turbine Company, of Trenton, New Jersey, U.S.A. We commend this book to the attention of water-works engineers.

Air Heaters.—Tubular heaters for heating air by steam, suitable for factories and drying plants and a special type of parallel flow heater for high-pressure steam, both made by the Victoria Tube Company, Limited, Great Bridge, Staffordshire, are described in catalogues received from the company's representative, Mr. A. Fleming Browne, 33, King-street, Covent Garden, London, W.C. 2.

Electric Crane Control.—Control gear for cranes, especially those of the overhead type used in foundries, workshops, yards, &c., is the subject of a special catalogue issued by Messrs. S. H. Heywood and Co., Limited, Reddish, near Stockport. This booklet is worthy of attention where a large amount of work has to be carried through and quick, accurate lifting and travelling is important.

Ball Bearings.—A catalogue of ball bearings and balls, notable for its compact and clear arrangement of particulars, has been received from Messrs. Rudge Whitworth, Limited, Sparkhill, Birmingham. The lists include journal and single and double-thrust bearings in light, medium and heavy patterns, with a very large range of sizes of each ; bearings for magneto drives are also listed.

Ebonite.—Ebonite, vulcanite and hard rubber are names given to the same material, which is a rubber product manufactured in a great variety of moulded forms as well as in rods, tubes and sheets. A catalogue to hand from Messrs. Siemens Brothers and Co., Limited, Woolwich, contains an explanation of its properties and uses, with lists of about 80 diameters of rod, 100 sizes of tube, and 50 thicknesses of sheets.

Tools for Turret Lathes.—A new edition of their catalogue of tools for the turret lathe received from Messrs. Alfred Herbert, Limited, Coventry, shows a great variety of accurately-made auxiliary attachments enabling many ordinary and specially difficult operations to be performed rapidly and cheaply. In this case "tools" has a very elastic meaning as it includes not only tools proper but special holders, heads, auxiliary slide rests, screwing, forming, recessing and other gear.

Driving Chains.—Messrs. Hans Renold, Limited, Didsbury, Manchester, have sent us two booklets on driving chains which will be of much practical interest to engineers. One gives very fully and clearly the technical information required in selecting a chain drive, while the other deals especially with the application of chain drives to machine tools—chiefly heavy motor-driven machines. In both publications lists of chains are given in dimensions, strength, power at given speeds, &c.

Special Steels.—The great variety of special steels, particularly tool steels, and the careful treatment both in working and tempering required to obtain the best results from each, is somewhat impressively forced upon the mind by a perusal of the catalogue sent to us byMessrs. R. B. Hodgson and Co. (Sheffield), Limited, Sentinel Steel Works, Sheffield. The information given, which is well arranged and carefully indexed, will be useful both in practical work and in making up specifications and estimates.

Electric Driving of Machine Tools.—The whole question of the advantages of driving each machine tool by a separate motor is reviewed in a catalogue issued by the Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester. The cases discussed are chiefly heavy machines requiring up to 50 h.p. and down to 2½ h.p. The system is, of course, largely used for particular machines, and the advantages of dispensing with shafting and fixing machines without regard to the lining-up which shaft transmission imposes, commands increasing attention. There are also obvious advantages in having standard types and sizes of motors which can be easily exchanged when repairs become necessary. The catalogue will be found very helpful on all aspects of the question.

Boilers.—Two catalogues dealing with Lancashire boilers and boiler fittings are to hand from Messrs. Galloways, Limited, Manchester. These are made in sizes to suit all general purposes, with a maximum of 30 ft. length and 8 ft. to 9 ft. diameter. The largest sizes are extensively used in multiples or batteries, in electrical generating stations, &c. The working pressures in pounds per square inch are generally 120 or 160, although they are made for pressures up to 225 lb. per square inch and higher. The improved type is made with dished end plates, and also with the two furnace flues joining into one broad flue stayed by Galloway tubes. The fittings catalogue includes all required mountings, fittings and connections, except superheaters which are described in the boiler catalogue. Very little superficial change has been made in these boilers for many years, but a careful reading of the descriptive matter with its illustrations of details of riveting, staying, gussetting and other joints and strengthenings shows how much careful study has been given to remedying the faults of earlier designs.

AUTOGENOUS WELDS OF LOCOMOTIVE FIRE BOXES.—The dearth of copper has forced German railway men to make their fire-boxes of copper last as long as possible. According to Weese, chief of the railway shops at Magdeburg-Buckau (*Zeitschrift des Vereines Deutscher Ingenieure*, September 3), experienced men can carry out repairs better by welding than by riveting and bolting, even in cases of extending the boxes. Careful work is, of course, required. The gas is the customary mixture of acetylene and oxygen ; and excess of the latter is to be avoided. The white core of the flame should not be allowed to touch the piece as it contains free oxygen, and the core should be sharply defined and not be hazy in its outline. A wire, 5 mm. or 6 mm. in diameter, of Canzler alloy is recommended as solder; this alloy, named after its manufacturer, consists of copper, silver and phosphorus, the constituents of which reduce any cuprous oxide formed, which would spoil the weld ; a weld showing the brick-red colour of this oxide is considered hopeless. The heating is best done on both sides of the metal simultaneously with the aid of two burners, and for long welds a third man should always be ready to step into the place of a tired welder.